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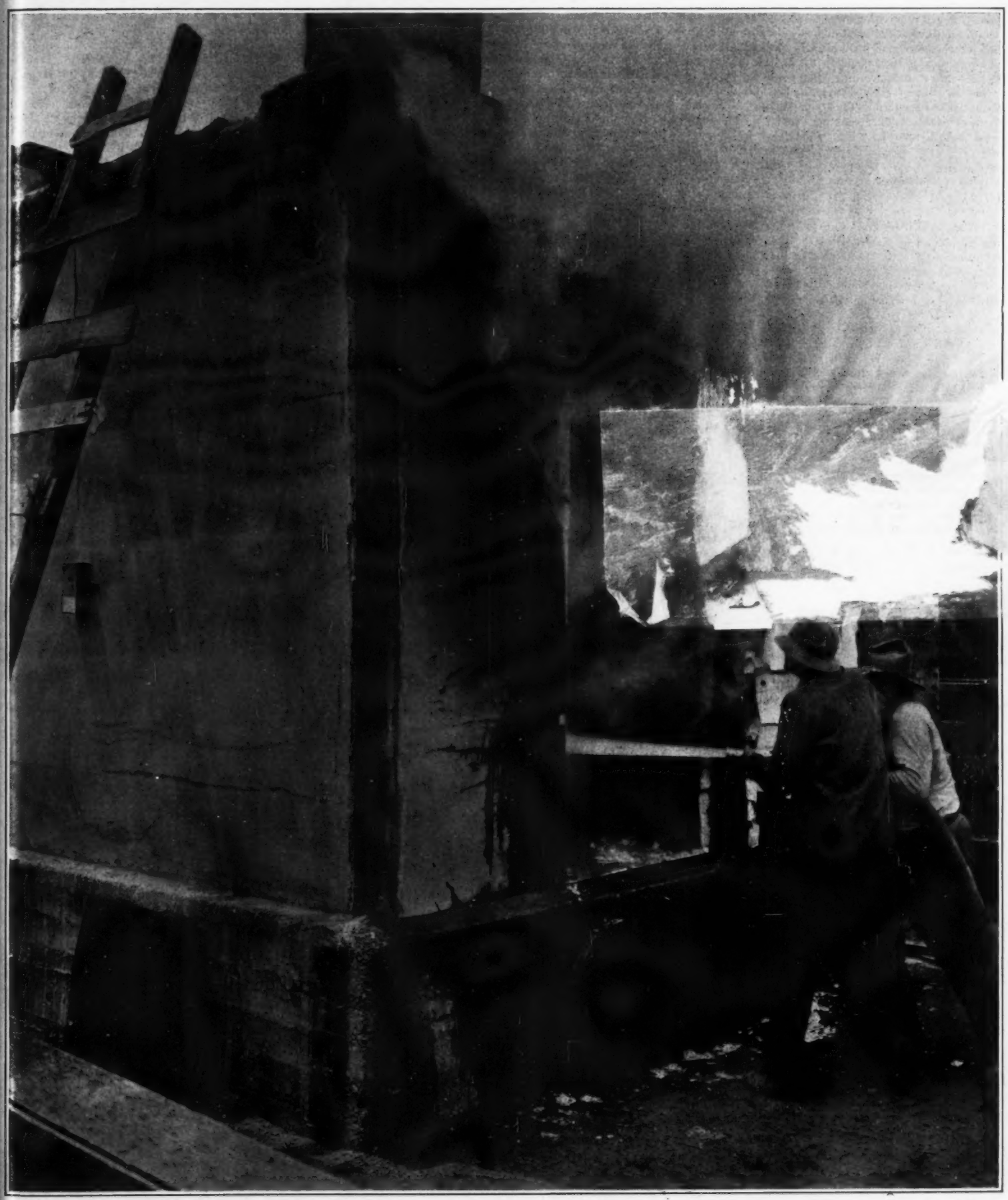

Applying Water—Partition Test.

TEST OF FIREPROOF CONSTRUCTION FOR THE CITY OF NEW YORK.—[See page 360.]

Evolution from the Standpoint of Physics—II*

The Principle of the Persistence of Stable Forms

By Alfred J. Lotka, M.A., D.Sc.

Continued from SCIENTIFIC AMERICAN SUPPLEMENT, No. 1952, Page 346, May 31, 1913

THE first result which flows naturally from our reflections on evolution from the standpoint of physics is a systematic arrangement of the subject-matter.

As primary subdivisions we shall have "kinetics" and "statics" of evolution, according as we center our attention, on the one hand, upon changes in distribution and the velocities of such changes, or, on the other hand, upon steady states (including equilibria).

We may then further distinguish between the transformations of matter,† or the accompanying transformations of energy. The resulting scheme therefore presents itself as follows.‡

Physics of Evolution	Kinetics	Transformations of Matter.
	Statics	Transformations of Energy.

Let us turn, then, first of all to a consideration of the transformation of matter, i. e., the changes in the distribution of the mass of a given system among its several component parts.

The general problem naturally resolves itself into a number of subsidiary problems, namely, the separate study of rate of growth (or decay) of the several components of the system.

A perfectly general treatment of this subject we shall not attempt here. We shall restrict our observations to a certain, still very general, class of cases which are of special interest.

Among evolving aggregates there is an important class which are composed of numerous individuals resembling one another more or less closely. A typical example is furnished by a population of living individuals, say a human community. It is characteristic of the mode of growth of such aggregates, that it appears as a balance struck between a rate of decay or elimination and a rate of formation of new individuals. Thus in the simple case of an isolated population, the rate of increase $\frac{dN}{dt}$ in the number N of individuals is obviously the difference between B, the total birth rate, and D the total death rate,

$$\frac{dN}{dt} = B - D \qquad (1)$$

In general, both B and D depend on the distribution of ages in the community, as well as on various other factors. However, the age distribution itself is not fortuitous, but under conditions otherwise constant, tends toward a certain definite type.§ It will be convenient for the purposes of theoretical discussion to suppose that this fixed age distribution is actually established; B and D and $\frac{dN}{dt}$ are then simply functions of external conditions and of the permanent characteristics of the aggregate or population.

We see then that the discussion of the factors which determine the rate of growth of such an aggregate, resolves itself, as expressed symbolically by the equation (1), into the discussion of the factors on which depend B, the rate and addition of new elements, and D, rate of elimination of existing elements from the aggregate.

Now, as regards the first of these two classes of factors, in certain special cases, such as that of a system in chemical reaction, they are of purely physical character; but in the case of organic evolution, to which our principal attention is here devoted, it is at this point that we should find it most difficult to apply directly purely physical considerations, however much it may be desirable that we should do so. Indirectly, however, we can at any rate in certain cases‖ gain some information regarding B from a knowledge of D. Now D depends very largely on features that can very well be discussed from a purely physical point of view. What happens in a given population of living organisms is that out of, say, one million born, a certain fraction l_x survives any given age x.¶ If the general conditions of the system are constant, we may assume that the function l_x is independent of the time and represents a characteristic function of the type of population under consideration.

Now the death rate D depends in a definite way upon this characteristic function l_x. Hence the investigation of the dependence of the death rate D upon physical factors resolves itself into the discussion of the relation between l_x and the physical properties of the particular type of population under consideration. Now the function l_x defined above is a measure of the probability, at birth, that a given individual picked at random from among the newly born shall reach age x. It is in fact the function tabulated in the "life table" of the actuary.

As the last result of our analysis we see therefore that the discussion of the factors which determine the velocity of growth of an aggregate of living organisms resolves itself into the study of the physical properties of the type under consideration, in their relation to the probable length of life of the individual.

Now the probable length of life depends on two groups of physical properties of the organisms, which we may denote collectively as its faculty of:

1. passive resistance,
2. active opposition,

to conditions unfavorable to life.

Among the unfavorable conditions with which an organism may have to contend there is one against which all living organisms quite generally must be protected, namely, lack of food. Now there are two classes of food which differ from one another in certain essential respects, and it so happens that the majority of organisms live principally on food of one or else of the other class.

It lies in the nature of things that food of the first class, *inorganic food*, that is to say, radiant energy (light), gases (carbon dioxide) or dissolved salts, comes to the organism spontaneously, by processes (radiation, diffusion) in which the organism itself is essentially passive. Food of the second class, on the other hand, *organic food*, occurs in discontinuous masses, and even in the most favorable case will, without some action on the part of the organism, come to it at best only in limited quantities. Accordingly, we meet in nature with two fundamental types of organisms, corresponding to the two classes of food mentioned above.

1. An essentially passive type of which the higher green plants are the characteristic example;

2. An essentially active type represented in its most characteristic form by the more highly organized animals.††

From the standpoint of physics the characteristic feature of the organisms of the second type is that they are provided with a "mechanism," or "system," which enables them to utilize a portion of the energy at their disposal in such manner as to react upon their environment and to secure thereby a further supply of energy, an indispensable condition for the maintenance of their life.

If we analyze from the viewpoint of physics the character and *modus operandi* of this system, we reach the following conclusions:

Inasmuch as the food of these organisms occurs in nature in localized masses, their "actions" must in some manner be made functions of external conditions. But in the first instance their actions are necessarily functions of the state of the organism itself. There must, therefore, first of all be established a suitable relation between the external conditions and the internal state of the organism. In other words, a "representation"‡‡ of the external world must be formed in these organisms. To do this is the function of the so-called sense organs or *receptors*.

Secondly, the organism must be provided with suitable means whereby it can react in an appropriate manner upon the external world. These organs (e. g., our hands, feet, etc.) we may speak of as *effectors*.

And lastly, means must be provided whereby a given signal received through the sense organs or receptors calls out the proper reaction: We will speak of these as *adjustors*. The action of these adjustors in their most highly developed form involves the spiritual phenomena of consciousness and intelligence. It is at this point that mental phenomena react upon the world of physical events, in accordance with the principle considered in the opening paragraphs of this paper. So far as we are able to judge, consciousness appears to be essentially an auxiliary of the active organisms living on organic food. The somewhat restricted class of carnivorous plants also, which capture living prey and consume it, possess definite sense organs, receptors and effectors. It would seem that we owe the development of our mental faculties to the nature of our food. In our present state of evolution our mind with its auxiliaries fulfills of course a number of secondary functions, and these are of such broad scope and importance (to say nothing of their æsthetic and ethical value) that we are perhaps ordinarily inclined to look upon them as the primary functions. But all our sense organs bear the stamp of having been developed primarily for the purpose of procuring us our food. Thus, for example, in man, eyes, nose, ears, and the sensitive surfaces of our finger tips, in which our sense of touch is principally concentrated, are all directed forward. Now forward means "in the direction of our natural mode of progress," and this direction in the great majority of cases is determined by the position of the mouth on the body of the organism.§§

The sense organs (receptors), limbs (effectors), under the control of suitable central organs, such as a brain (adjustors), which last may also be the seat of intelligence, do not of course provide absolute protection of the organism against destruction. Their function is to increase the probable length of life as measured quantitatively by the function l_x. Among animals, other things being equal, those will carry off the victory in the struggle for supremacy, whose receptor-effector system‖‖ is most efficient in directing available energy into channels favorable for their life.

But in all their doings the active forms of organisms work at the expense of available energy. This is merely repeating in other words the statement which was made above, that the action of living organisms upon nature is limited to a directing influence. They take advantage of the downward stream of energy, directing it as suits their purpose, with an action analogous to that of a catalyzer, though they are quite powerless to reverse this stream. Throughout, in the infinite variety of the interactions between both living and the non-living matter, there reigns the immutable physical law, according to which the course of events in time proceeds in one irreversible direction. In the words of the German poet Goethe:

"Nach ewigen, eh'rnen,
Grossen Gesetzen
Müssen wir alle
Unseres Daseins
Kreise vollenden."

. . . . . .

(To be continued.)

Move to Reclaim Farm Land

COLONEL CHARLES M. JARVIS, president of the Connecticut State Agriculture Society, has started a novel "back to the land" movement by soliciting subscriptions from all the manufacturers of Connecticut to meet the cost of interesting present and prospective farmers in tilling the soil on scientific principles. In that way, he says, the cost of production can be reduced to a degree which will more than compensate for any burdens that a lower tariff may impose.

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* Translated and revised for the SCIENTIFIC AMERICAN SUPPLEMENT by the author from the *Annalen der Naturphilosophie.*

† Whether matter has an independent existence apart from energy, or whether it merely represents certain energy-complexes (see Wilhelm Ostwald, Vorlesungen über Naturphilosophie, 1902, pp. 169-170) is for our present purposes immaterial. In practise it is found useful to regard certain transformations as transformations of matter. There seems to be no difficulty in deciding for which cases this treatment is applicable.

‡ This arrangement of our subject is identical with that adopted by Nernst in his Theoretical Chemistry. Inasmuch as we have learned to look upon a system in chemical transformation as a special case of evolution (compare also Perrin, *loc. cit.*) this parallelism is only to be expected.

§ See Lotka, Am. Jl. Sci., 1907, p. 202; Science, xxvi, 1907, p. 21; Phil. Mag., April, 1911, p. 435; Jl. Washington Ac. Sc., I, 1912, p. 67; III, 1913, pp. 241, 289.

‖ One such case is that mentioned above, where the age distribution in the population is fixed. See Lotka, loc. cit. The second case is that in which the population is stationary. Here, of course, the birth rate is equal to the death rate, $B = D$.

¶ Precisely similar considerations can be applied to a system of molecules in chemical reaction. See Am. Jl. Sc. loc. cit.

†† There are, however, numerous exceptions to this general rule—parasitic and saprophytic plants which, though of the passive type, nevertheless live on organic food; insectivorous plants, which in general build are of the passive, plant type, but possess active prehensile organs; and lastly, animals like the green fresh water polyp (*hydra*), which, like plants, contain chlorophyl, by the aid of which they can absorb sunlight and utilize it in the assimilation of carbon dioxide.

‡‡ In the mathematical sense.

§§ Compare E. H. Starling, Science, 1909. See especially p. 394.

‖‖ In the case of civilized man we must include in the receptor-effector system those artificial auxiliaries which fulfil similar functions as our sense organs, brain and limbs—that is to say, such devices as the microscope, telescope, telephone; calculating machines; tools, engines, etc. The evolution of such auxiliaries follows the same laws as the evolution of our natural organs (see Prof. W. Ostwald's article, "Machines and Living Organisms," SCIENTIFIC AMERICAN SUPPLEMENT, July, 1910, p. 55), although the mechanism by which they originate is essentially different from the physiological processes involved in the development of our natural sense organs. Compare also Wiener, *Die Erweiterung unserer Sinne*, Leipzig, 1900.

The Treatment of Bacteriological Infections by Chemical Means*

Test-Tube Experiments Often Misleading

By Dr. F. Blumenthal

THE hopes which are to-day being based upon chemotherapy—the healing of disease by the application of remedies produced in the chemical laboratory—are in part the result of disappointment sustained in the field of serum therapy. For the wonderful success which v. Behring reaped by the serum treatment in diphtheria has unfortunately not been followed by similarly favorable results in most other infectious diseases. But this is not the sole reason for the present attitude of hopefulness in the field of chemotherapy. The basis for this lies largely in discoveries made in recent years, which have instilled new life into the work in chemotherapy as applied to the treatment of infectious diseases. In 1894 Dr. v. Behring expressed with resignation the opinion that attempts to combat infectious diseases by medicinal means had proved vain, because the substances which are noxious to the bacteria are even more harmful to the human organism. More recent experiments (1906) by Ehrlich and Bechhold, on the effect of phenols on animals affected with diphtheria, gave a similarly negative result, for it was found that the compounds in question, while highly effective in the test tube, lost their power when presented to the disease germs within the body.

And what are the new discoveries which have raised our hopes anew?

Hitherto the course followed in seeking bactericidal medicinal agents was to bring the material under examination into direct contact, e. g., in the test tube, with the microbes, and to determine the highest degree of dilution at which the substance still showed an effect upon the germs. *Only those substances* were then tried in actual experiments upon animals, which had displayed a high degree of activity in the preliminary test-tube trial. It was assumed as self-evident that a chemical substance which showed little effect in the test tube, would be still less efficient in the animal body.

But a surprise was in store: The substance known as atoxyl was found to be a highly efficient remedy against the trypanosome, the parasite which causes sleeping sickness, although in the test tube it had no action whatever upon these organisms. A similar observation was then made by Morgenroth and Halberstädter, with ethyl hydrocuprein, a quinine derivative which displayed most excellent curative powers against pneumonia in mice, although *in vitro* it showed little or no action against the bacillus of this disease, the pneumococcus. And quite recently the same observation has been made by Franz Blumenthal in the case of a number of mercury compounds. From this it seems to follow that the action of a drug within the animal economy can not be gaged from its behavior toward disease germs in a test tube experiment.

But this is not the only new fact revealed. Until fairly recently it was customary to give preference, of two medicinal preparations, to the one which had shown greatest effectiveness and least poisonous character in preliminary tests upon animals. Experiments with arsenic and mercury preparations have shown recently, that the assumption here involved is quite unwarranted; some drugs which were highly efficient in man had comparatively little effect upon the test animal, and *vice versa*. In fact, had the physician always been guided by animal expriments, it is probable some source of our most valuable medicaments would never have been discovered, such as for example salicylic acid as a remedy for rheumatism.

This fact, that animal exprimentation is in this respect apt to be so misleading, requires explanation. Any such explanation must be based upon a knowledge of the mode of action of bactericidal substances. This action may be *direct* or *indirect*.

We have seen that a direct action is not observable in the test tube in certain cases. Hence we must suppose that at least a slight chemical reaction occurs between the human economy and the substance introduced, before the latter acquires its bactericidal properties. A comparatively direct action probably occurs where the effect follows close upon the introduction of the drug into the body. Thus for instance in the case of arsenical drugs the disease germs are found to have disappeared from the body only a few hours after administration of the medicament. The matter is probably different in the case of indirect action. Here the body must first produce the antidote from the substance introduced. This may happen by the fixation of the drug in some organ, from which the new body is produced, or by the stimulation of protective agents naturally provided in the body. In such cases the action does not become felt in a few hours, but only after a considerable lapse of time. Thus in the case of the administration of mercury a deposit of this element is first formed in the liver. At the same time the human body itself may produce antitoxins. Thus Böhnke has shown that the formation of antitoxins in animals treated with diphtheria serum was much increased by the administration of salvarsan, and that the same drug increased the formation of the antitoxin of meningitis seventeen times.

It is to be expected that where the action is comparatively direct, there will not be so marked a difference in the action of the drug in man and in animals. On the other hand, where complicated indirect effects are involved we shall expect greater variations in the effect of the drug from species to species. Another point which has to be considered, is that in many instances the course of the disease is more rapid in animals than in man, so that the animal may die before a drug that is slow in action has had a chance to produce its effect. Moreover, the speed of reaction of the drug introduced varies much from one individual to another even within the species, and must therefore be expected to vary still more from one species to another.

It is therefore not surprising to find that the results of animal experimentation on the effect of drugs in the treatment of disease can at best be only a somewhat unreliable guide in the investigation of the remedial properties of new substances.

*Translation, slightly abridged, from *Die Umschau*.

The Lubrication of Machinery

Forced Feed Should Be Used Wherever Possible

By Walter J. May

To provide for the proper lubrication of machinery of any kind two things are necessary—suitable oils or greases, and efficient lubricators fitted for the positions which they are to occupy, and also fitted to maintain a supply of the clean lubricant. To supply a mixture of oil and dirt to any machine is likely to cause serious injury, and often to supply an unsuitable lubricant is to get hot bearings or seized journals, points to be carried in mind at all times.

The object of lubrication is to place a film of oil or other suitable material between the surfaces of the shaft and bearing, or between two moving surfaces, so that instead of the metal being in close contact, and so grinding away, they will be sliding on the lubricant. This in itself makes a careful selection of the oil, grease, or other substance used, a matter of considerable importance, because if one used a light cycle or sewing-machine oil in a heavy machine it would not carry the weight, the moving surfaces then simply coming into contact. Equally, if we use a heavy oil or grease in a light machine it will either not spread properly, or it will retard the machine, owing to its resistance. Any form of lubricant which has a chemical action on either one or both of the surfaces to which it is applied should be avoided, and in the case of oils and greases used in steam cylinders it is important that their action on the boilers should be considered where the exhaust steam is condensed and the water again used.

The majority of things which have to be lubricated require a constant, although small, regular supply of whatever material is being used, it being insufficient to pour down a pint of oil in the morning and then forget all about the matter for the rest of the day. Where such a practice obtains there is a continual demand for liners and new brasses, and the results are generally of an unsatisfactory character. This applies also to greases and solid lubricants generally, and unless the supply is constantly replenished something has to suffer.

There are a good many devices to secure a regular supply of lubricant to bearings, some of the appliances being very ingenious; but unless some form of forced feed be used there is always a doubt as to the efficiency of the work being performed. Some of the appliances used are also very liable to fail from very trivial causes, and damage is easily done before it is noticed where such happens to be the case, because the men in charge of machinery are apt to trust too much to the automatic working of such appliances, and thus unconsciously neglect what they would pay particular attention to if the weak appliances were not in use. Even the bottle and needle lubricators need closely watching, unless they are on absolutely clean bearings, as a very little will obstruct the flow of oil and permit the bearings to become dry, or nearly so. With a forced feed while the apparatus is in motion the lubricant must flow to where it is directed, while in the event of the apparatus failing to work, such would be more readily seen than where a simple automatic action would be noticed—points worth attention. Forced feed can be applied to both solid and liquid lubricants, and in nearly every position. Even colliery tram wheels, conveyor rollers, and suchlike things could have a forced-feed lubricator of simple design fitted to each one separately, the labor of keeping such lubricators charged being very small, while the grease saved would pay for their cost in a very short time.

In dusty and otherwise dirty places the question of lubrication is usually a difficult one, as it is one of the hardest things in running a mechanical business to insure cleanliness in any place not in full view. The oilers will not clear away the dirt before squirting oil in and around the oil-holes, and in most cases, on opening the bearings it will be found that the channels are filled with dirt, and what little oil reaches the bearing is so mixed with grit that it does quite as much harm as good. Of course, in dirty places it is necessary to be specially careful; but there is no real difficulty provided cleanliness is an imperative duty. There should be a rule made and adhered to that the accumulated dirt be removed before oiling, and some little care may also be taken in providing small —and, possibly, homemade—appliances for the throwing off of dirt from the bearings as much as possible, while automatic scrapers should remove exuded grease and dirt from the shafting and ends of bearings, these being easy to design and make where there is a workshop on the place. Preferentially forced-feed lubricators should be used wherever possible, as these can be obtained to give a positive supply of either oil or grease, as desired, and if well arranged the dirty stuff from the bearings will work out at the ends and be scraped off, so that all dirt will be kept out of the moving parts of the machinery. Some things are difficult to deal with anyhow, as, for instance, the bearings of the bottom sprocket of an elevator working in a boot on wet, gritty material; but, of course, such cases are not general, and only affect a few trades.

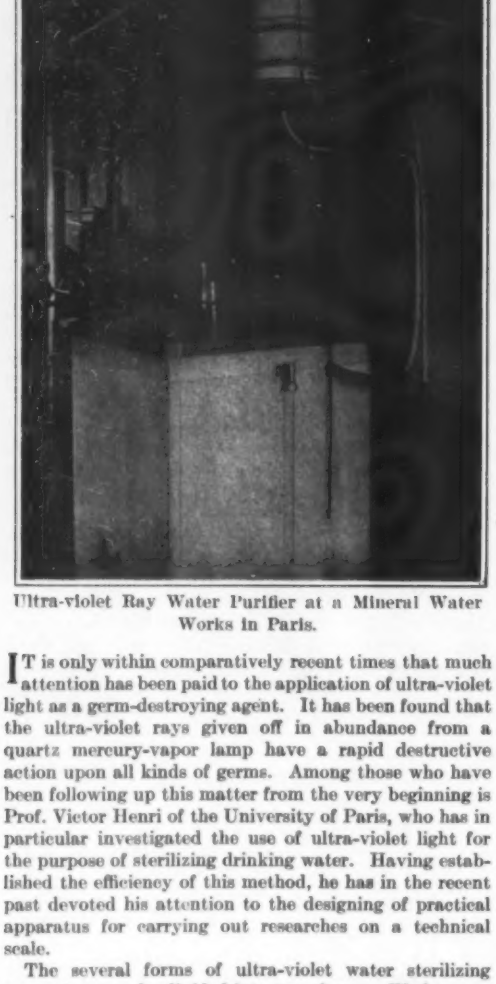
Dry lubrication can be used with a good many things, either plumbago or steatite being used, and in regard to this some little skill has to be exercised. Either the lubricant can be used absolutely dry or mixed with just enough tallow to prevent it from flying about: which method is best being very much dependent on local conditions. The object is to obtain as little friction as possible, and to do this two polished surfaces are necessary, and to these must be added a greasy working lubricant such as those mentioned, with or without some greasy adhesive to prevent them from blowing away. Where it does not matter about the dust it is better to do without the adhesive; but where tallow is used, the smallest amount possible to effect its purpose should be used, and to facilitate the work of mixing, the tallow should be melted and the lubricant warm.

In some cases the dry lubricant can be best used in the form of a pencil or bar after being agglutinated together with tallow or some other medium, the bar being made to slightly rub the surface over which it passes by means of an adjustable feed; but in this case the special requirements of each case will have to be arranged for. In any case, after the surfaces are once lubricated, only a small quantity of lubricant will be needed to keep them in good order, and for this reason very careful adjustment must be made.—*English Mechanic and World of Science.*

Water Sterilization by Ultra-Violet Light

There Is Nothing New Under the Sun: An Imitation of Nature's Process

By the Paris Correspondent of the SCIENTIFIC AMERICAN



Ultra-violet Ray Water Purifier at a Mineral Water Works in Paris.

IT is only within comparatively recent times that much attention has been paid to the application of ultra-violet light as a germ-destroying agent. It has been found that the ultra-violet rays given off in abundance from a quartz mercury-vapor lamp have a rapid destructive action upon all kinds of germs. Among those who have been following up this matter from the very beginning is Prof. Victor Henri of the University of Paris, who has in particular investigated the use of ultra-violet light for the purpose of sterilizing drinking water. Having established the efficiency of this method, he has in the recent past devoted his attention to the designing of practical apparatus for carrying out researches on a technical scale.

The several forms of ultra-violet water sterilizing apparatus may be divided into two classes. We have on the one hand large sterilizers intended for the treatment of the water supply of a city, a number of which proved to be very successful at a recent competitive test at Marseilles. On the other hand a number of small apparatus have been designed for individual use for domestic purposes or in small plants of various kinds.

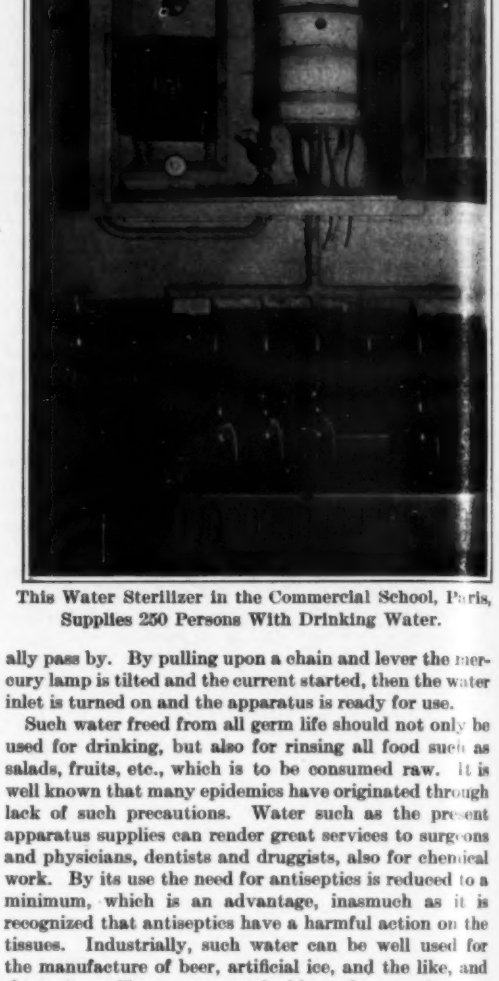
While in one sense water sterilization by means of ultra-violet light is a very recent invention, in another sense it might be said to be older than the human race, inasmuch as it is continually going on in nature. Sunlight is one of the most powerful germ-destroying agents known, and to it we owe for the greater part such natural purification of water as goes on continuously in streams and lakes. It is remarkable how rapidly a river, heavily polluted by the sewage of a city, is freed of its microbes by the action of sunlight, and made practically harmless to the health of the community. It is recognized that this action is due to the ultra-violet rays which form part of the sun's light.

Sewage, however, which is run off through closed conduits does not undergo this natural purification, thus proving that it is actually due to sunlight.

In tropical countries where the normal temperature is highly favorable to development of microbes and leads to a quick growth of germs, but where at the same time the beneficial effect of the immense amount of light is felt, this glare of the sunlight undoes what the heat has been engaged in doing, so that it obliterates the germ life whose development is chiefly due to the high temperature. We mention this fact only to show that the application of light for sterilizing water is not an artificial process like, for instance, the addition of chemicals, but is a process to which nature herself has been pointing us from the beginning of our era. If it has taken a long time for scientists to study this problem of sterilizing water by artificial illumination, the reason is twofold. First, until recently the phenomenon was not analyzed and shown to be due to the germ-destroying action of a certain part of the spectrum, namely, the ultra-violet light, and secondly, powerful sources of such light have only been known in the last few years.

The spectrum of sunlight is extremely rich in ultra-violet rays, but in the form in which this light reaches us, a very great part of these rays are absorbed, as it is well known that air absorbs short light waves. We can readily observe the effect of the ultra-violet rays in localities where the atmosphere is rare, as at high altitudes, and the well-known cases of peculiar type of sunburn which are met with in the Alps are due to the excess of ultra-violet rays in the sunlight in such places.

We shall describe here two types of small sterilizers for use. In private dwellings, in schools and like institutions and in large buildings of various kinds, as well as for industrial use in many plants, all that is needed is to have the building wired for electric current as is commonly the case in large cities and towns nowadays. A small enameled tank contains a mercury vapor lamp in its upper part, and is kept half-filled with water, so that the light falls upon the surface of the water. The water is made to pass several times under the influence of the rays by suitably arranged baffle plates. The tank is connected by a pipe with the water mains, and the sterilized water is drawn off by a tap at the bottom. The rate of flow depends upon whether the water is clear or not, as cloudy water hinders the effect of the rays, but with clear water an output of 130 gallons per hour is attained with the present tank of but 20 inches height. A simple electrical apparatus adjusts the current to the standard rate once for all, and an electric bell rings whenever the burner is for any reason put out of circuit and ceases to give the rays, so that no unsterilized water can accidentally pass by. By pulling upon a chain and lever the mercury lamp is tilted and the current started, then the water inlet is turned on and the apparatus is ready for use.



This Water Sterilizer in the Commercial School, Paris, Supplies 250 Persons With Drinking Water.

Such water freed from all germ life should not only be used for drinking, but also for rinsing all food such as salads, fruits, etc., which is to be consumed raw. It is well known that many epidemics have originated through lack of such precautions. Water such as the present apparatus supplies can render great services to surgeons and physicians, dentists and druggists, also for chemical work. By its use the need for antiseptics is reduced to a minimum, which is an advantage, inasmuch as it is recognized that antiseptics have a harmful action on the tissues. Industrially, such water can be well used for the manufacture of beer, artificial ice, and the like, and the system will prove most valuable to the manufacturer of mineral water. It will render great services for washing of bottles for liquids such as milk, cider, beer or vinegar. It has also been shown that the use of sterilized water for washing butter has a remarkable influence upon the keeping qualities of the product. After washing with such water, butter was kept for a month without spoiling.

One of our engravings represents a sterilizer of this kind fitted in the Commercial College at Paris, where it sterilizes all the drinking water used in the school, whose attendance figures about 200 to 250 persons. The director states that it gives perfect satisfaction. It will be seen that there are a number of outlets from the same tank, and the whole apparatus is contained in a small cupboard.

We also show a sterilizer as used in the works of a mineral water firm; a large storage tank below serves for holding the pure water. It should also be mentioned that the Northern Railroad is commencing to adopt it for the waiting rooms of the stations, the first one having been lately set up in the North Depot at Paris.

Economy of a Works Hospital System

THE medical department of a well-known manufacturing firm of Worcester, Mass., has collated the results of the year 1912 in their effect upon shop efficiency. They show that the systematic medical and surgical care of employees under intelligent, aggressive direction, coupled with organized sanitary inspection of works, is a direct source of financial profit, as well as a powerful influence on the physical health and the earning power of the workmen. The percentage of idle hours—the time that men are absent from their work—has been reduced from about 3 to 1½. The sick or injured workmen who receive treatment at the company's hospital average 19.2 hours less of lost time than those employees who do not avail themselves of the opportunity urged upon them, and instead go elsewhere for professional assistance, or, as often happens, receive no attention at all. The medical department's effort to reduce the loss of working time has been extended by the company to a radical curtailment in absences from the works because of personal reasons other than impaired health. Tuberculosis has been stamped out; the cases which were discovered, less than 10 all told, were taken in the incipient stage, and already some of the patients are back at work cured.

A singularly illuminating commentary on the value of prompt treatment of injuries is the fact that in all the 800 accident cases treated in the hospital since its establishment 20 months ago, only one case of septic poisoning has occurred, and that a trivial affair, due to the patient's removing the dressing. The influence of the system in making more cordial relations between workmen and owners has been made evident in many ways, and increases as the work is better understood.

A crowning proof of the effectiveness of the department is that the liability insurance company has granted a premium rebate which covers practically the entire cost of the medical and sanitary departments. In other words, the system is paying its way by the reduction effected in accident risk under the workmen's compensation act.

The saving of idle hours is no mean item of economy. The system applies to some 900 men. A reduction in lost time from 3 per cent to 1½ per cent means, roughly, a decrease from 70,000 to 35,000 hours. The production saved is the labor of 600 men for one week of 60 hours. The gain is greater than this, however, for the influence of absence from work may extend beyond the actual labor which the workman fails to perform. The loss from the idleness of certain highly skilled men may be serious in upsetting the balance of production. In such cases the medical department has the chance to co-operate directly with the head of the department, perhaps to tide the man over in his illness until certain necessary work has been completed.

One revelation of the records is that a wide variation exists between departments as to the number of idle hours due to reasons other than that of health. The personality of the foreman is involved, including his leniency as to requests for leave of absence, his degree of indulgence where men fail to appear for work, and his friendliness toward individuals. The rule has been made that a workman is dropped from the rolls automatically if he is absent for a period of more than seven days. Upon his return he must apply for work at the office of the superintendent and must be hired over again, even to the making out of a new card. This gives the superintendent the chance to watch his men and the foreman is eliminated as the judge of the case. The rule works against indulgence in an extra day or two of idleness at the expiration of a period of sickness, and the chronic idler is soon detected.—*Iron Age.*

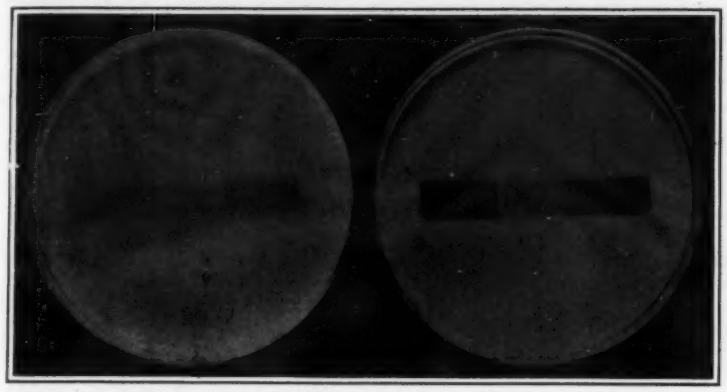


Fig. 1.—The Action of Rennet Extract on Casein Suspended in Agar in the Presence and in the Absence of Acid-forming Bacteria.

The same number (902) was placed beneath both plates at the time the photograph was taken. The digestion of the casein in the presence of the acid-forming bacteria has rendered the medium transparent and the number apparent, while in the absence of the acid-forming bacteria the digestive action has been almost nil, as is seen by the opacity of the specimen on the left.

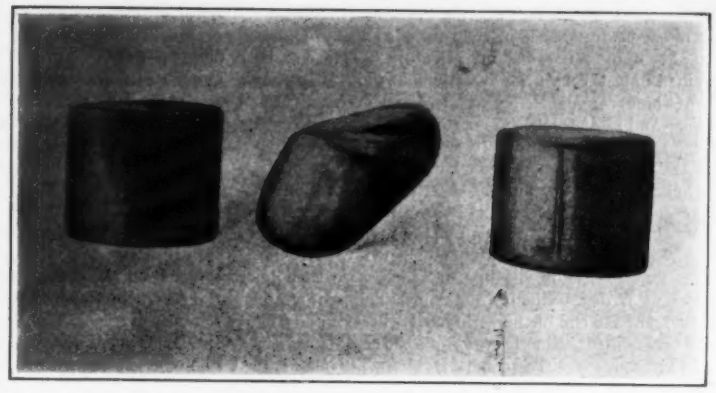


Fig. 2.—The Hardening Effect of Acid on Cheese From Which All Sugar Has Been Washed Out.

On the left is a cheese made from normal milk by the usual process; in the center a cheese made from the same milk, the curd being washed free of sugar; on the right a cheese made from the same washed curd, to which acid had been added. The washed-curd cheese had no body and was a soft, plastic mass. The addition of acid restored the firmness of the body.

The Bacteriology of Cheddar Cheese*

The Rational Basis of a Fermentation Industry

By E. G. Hastings, A. C. Evans, and E. B. Hart

THE rôle of micro-organisms in the preparation and ripening of the various kinds of cheese is a problem that has attracted the attention of bacteriologists since the beginning of the science and since the establishment of the importance of micro-organisms in all decomposition processes. From the same raw materials—cow's milk, salt, and rennet, which is an extract of the fourth stomach of the young calf—a great number of varieties of cheese are prepared. These cheeses differ not only in texture, but more especially in flavor and aroma. From what is known of the importance of micro-organisms in the preparation of the products of the fermentation industries, it is evident to one who gives consideration to the question that undoubtedly micro-organisms are as essential in the making of cheese as they are known to be in the preparation of wine, beer, and other products.

In the making of wine and beer the desired changes are produced by a single form of life, the true yeasts, and in the preparation of any desired type of product attention need only be directed as far as the causal organism is concerned in order to insure the presence of the particular variety of yeast that has been found by experience to form a product that has the desired properties as well as to insure the absence of harmful forms. In the preparation of still other products of the fermentation industries, not only a single form of life is essential to produce the desired changes, but two or more are needed, one of which may work on a certain constituent of the raw material, the other on another, or the one may serve to make conditions favorable for the growth of the second, usually by the preparation of suitable food.

It is evident that as the number of kinds of micro-organisms that are needed to produce the desired changes in any product increases, the complexity of the problem of demonstrating the rôle of each of them is also greatly increased, and it may become most difficult to prove even whether any particular organism is absolutely essential in the preparation of the product, to say nothing of demonstrating its exact rôle. It is not to be supposed that a single form of life is responsible for the complex chemical changes that occur in the ripening of any particular variety of cheese, but rather that a considerable number will be involved.

The fermentation industries include those in which micro-organisms are essential for the production of the desired decomposition changes. In all such industries the quality of the product will depend on the raw material and the organisms that are used in the decomposition of that material. The preparation of cheese has not until recent years been classed as a fermentation industry, although it is one in which micro-organisms play a dominant rôle. Here, as in all other similar industries, if control of the quality of the product is to be obtained, knowledge must be gained concerning the essential biological agents.

THE BACTERIAL FLORA OF MILK.

In the case of many of the products of the fermentation industries the essential micro-organisms are contained in the raw materials, and the development of the methods of preparation of the products have been wholly empirical. Especially is this true of certain kinds of cheese, the methods of manufacture of which are in some cases centuries old. Even in the case of cheese to which at some stage in manufacture material containing certain micro-organisms is added the methods of manufacture antedate the science of bacteriology.

The sources from which micro-organisms enter the milk are much the same in all parts of the world. Any natural source, such as the interior of the udder, the dust from the animal, or even the utensils, will always furnish certain definite types of micro-organisms. By this is not meant that the flora of milk will always include these definite types and no others, but that certain forms will always be present. That this is true is shown by the fact that a sample of ordinary market milk, if stored at temperatures ranging from 60 to 90 deg. Fahr., will undergo a definite sequence of decomposition changes with almost unerring certainty. In this sequence three main groups of micro-organisms are prominent; first, the acid-forming bacteria that change the milk into an acid, semisolid mass, favorable for the development of the mold that is characteristic of milk—*Oidium lactis*. This mold, by its gradual destruction of the acid and the establishment of an alkaline reaction, makes it possible for the putrefactive organisms to develop. When the environment is changed this sequence of microbial life in the milk is also changed. For example, milk may be kept at such low temperatures that the acid-forming bacteria can not grow and the putrefactive bacteria appear first.

It is thus proper to speak of a characteristic milk flora. By some it is believed that this flora is so constant that fermentations that depart from the normal are to be looked upon not as due to the introduction of other forms of micro-oganisms, but most often to changes in the properties of the organisms or to changes in environment that favor the particular organisms which produce the abnormal fermentation. Slight changes in the composition of the milk may also have a determining influence.

As has been stated, the micro-organisms necessary for the preparation of most kinds of cheese are contained in the milk. Whether one form or the other is to develop in the cheese depends upon the environment established by the cheese maker. The manufacture of cheese is thus a problem in the ecology of micro-organisms.

DIFFERENCES IN COMPOSITION OF CHEESE.

The differences due to the methods of manufacture result in differences in composition of the cheese at the time it begins to undergo the ripening process, which is to determine whether the cheese is to be classed as one kind or another. The differences in composition of the fresh cheese are very largely in the amount of moisture present. Since the water that is left in the cheese is whey, carrying in solution sugar and other constituents of milk, the effect of differences in moisture is not only in influencing the texture, but also the composition of the cheese. The difference in moisture content between Cheddar and Camembert cheese is approximately 25 per cent. If it is supposed that the moisture of the cheese will have about the same sugar content as milk, this means that the sugar content of the Camembert cheese will be about 1 per cent greater than Cheddar; and since the sugar is all fermented, differences in sugar content ultimately result in differences in acidity.

One of the basal differences between Cheddar and Swiss cheese is that during the making of the first—that is, the operations before pressing—a large amount of acid is formed in the curd, while in the case of Swiss no such acid production occurs. Van Slyke and Hart, Boekhout and Ott de Vries, and Van Dam have shown that acid is held chemically by the proteins of cheese, while sugar is not. Thus if in the making of one cheese acid is formed, and in another not formed, the result will be a somewhat different composition, even though the moisture content of the two cheeses is initially the same.

Another difference in composition of cheese is caused by variations in the amount of salt and in the time at which it is added. This difference is an important one in the case of Cheddar and Swiss cheese. These differences in the initial composition are sufficient to exert a great influence on the types of life that are to grow in and on the cheese.

Each of the great commercial varieties of cheese presents a distinct problem for the bacteriologist, who should be able to demonstrate the constant presence of the essential groups of bacteria. It can not be expected here any more than in most decomposition processes that a single specific organism will be concerned, as in the causation of disease, but rather that groups of organisms will be present, the basis of grouping being largely biochemical. Neither can it be expected that one group will grow for a period, then disappear and be followed by a second, but rather that the sequence of development will be confused.

The work of Thom on Camembert cheese furnishes an excellent illustration. It has been shown that a definite balance between the various forms of life concerned is essential for the normal ripening of this cheese. If through methods of manufacture or through conditions of ripening this balance is destroyed, the cheese will not be typical.

The biological factors concerned in the ripening of Camembert cheese are the acid-forming bacteria, the Camembert mold (*Penicillium camemberti*), or its white form (*Penicillium camemberti* var. *rogeri*); *Oidium lactis;* and bacteria which together with *Oidium lactis* form a reddish slime on the surface of the cheese. If conditions favor the growth of *Oidium* lactis at the expense of the penicillium, the cheese will not be normal; if the mold is too luxuriant, texture is obtained but flavor is not. It is thus evident in the case of Camembert cheese too wide variations in the balance between the different forms of life can not occur if a cheese normal in texture and flavor is to be obtained. A large amount of work has been done on Camembert cheese and the necessity for the presence of the different forms established, but their exact rôle has not been shown and never can be until the chemist devises means of following in detail the complex chemical changes.

THE RÔLE OF ACID IN THE RIPENING OF CHEESE.

In the ripening process proper the acid resulting from the fermentation of the sugar by the organisms of the *Bacterium lactis acidi* group has an important rôle. As has been shown by numerous investigators, the sugar in the cheese is all fermented within a few days. It was shown by Babcock and Russell, also by Jensen, and by Van Slyke, Harding, and Hart, that rennet extract not only has a curdling effect but has a digestive action in the presence of an activating acid such as is present in the cheese. The rapid proteolysis occurring during the first part of the ripening process is largely due to the action of the pepsin.

* Bureau of Animal Industry *Bulletin*, No. 150.

Variations in the amount of rennet extract added to the milk result in differences in the rate of ripening, as has been shown by numerous investigators. This can be explained only through the variations in the pepsin content of the cheese. The action of rennet extract in the presence and absence of lactic organisms is demonstrated in Fig. 1. A 4 per cent solution of agar was added to sterile milk in the proportion of 1 to 1. A portion of the milk agar was heavily inoculated with a lactic organism and the plates incubated for 24 hours; the other portion was not inoculated. At the end of the period of incubation strips of filter paper were moistened with rennet extract and placed on the plates, which were then incubated at 37 deg. Cent. for one hour. The photograph was taken at the end of the period. It will be noted that in the presence of the lactic organisms the casein has been rendered soluble by the rennet extract, while in the absence of the organisms no such marked digestion has occurred. The digestion of the casein has resulted in the destruction of the opacity of the milk agar, so that a number placed beneath the dish can be read, while in the case of the milk agar from which the lactic organisms were absent no trace of a similar number can be distinguished. In the milk agar conditions are very similar to those obtaining in the production of cheese, the activating acid being of like origin.

THE PROTECTIVE ACTION OF ACID.

The putrefactive bacteria of the groups that are constantly present in milk, and hence in cheese, are unable to grow on account of the acid reaction which is maintained during the entire period of ripening. This protective action of acid was first demonstrated at the Wisconsin Experiment Station by Babcock and Russell, who removed the sugar from curd by washing in water. The cheese developed most undesirable odors and tastes, and bacteriological examinations showed liquefying bacteria to be numerous. If lactose, glucose, or cane sugar were added to the washed curd, the ripening process was much more nearly normal because the acid reaction was thereby restored, owing to the fermentation of the added sugar, and the putrefactive organisms were inhibited as in a normal cheese. In the experimental work on flavor development in Cheddar cheese, a number of cheeses were prepared from curd from which the sugar was removed by washing. In Fig. 2, a normal and a washed-curd cheese are illustrated. The washed-curd cheese was devoid of texture, being a soft, plastic mass and having no resemblance to cheese in odor and taste. On the right of the picture is a cheese made from the same washed curd to which acid had been added, with the result that the firmness was restored.

Radiations Old and New—II*

Corpuscular and Other Rays and Their Relation to Molecular Physics

By Prof. W. H. Bragg

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 1952, Page 342, May 31, 1913

WHEN, therefore, X-rays are projected into any material we must think of them as a stream of separate entities, each one of which has complete independence of its neighbors and pursues a life of its own. It changes to a β ray and back again; as a β ray it is liable to loss of energy and much deflection, so that those rays which do not pass through the body, but are held therein, end as electrons moving about in the body with the velocities of thermal agitation; that is to say, with those velocities which free electrons in the body must possess on account of the share which they take in carrying the heat of the body.

Now we may ask ourselves what will be the result if transformations continue to take place at these lower energies; for the moment let us assume that they do. Let us consider some substance like a block of metal. Within it we know that there are innumerable electrons traveling to and fro with various speeds. In their motion is stored up energy; the communication of heat to the body makes them dance more quickly. When the quicker motion is begun in one part of the body, diffusion hands on the motion to the rest; that is to say, heat has been conducted through the body. If we try to pass an electric current through the body, it is the movement of the electrons that constitutes the current. This is the accepted theory at the present time. It is even possible—but this is not accepted by all—that the energy of the moving electrons in the body constitutes the main store of heat therein. The electrons do not all move at the same speed, of course; but there is a certain well-known distribution of their energies about a mean value. At any time a certain percentage of the electrons are moving with speeds lying within definite limits, although the individuals possessing such speeds are continually changing. If we now take into account the transformations of which I have been speaking, we find that there must be X-ray quanta—this name will do for them as well as any others—in such numbers as to be in equilibrium with the electrons of every variety of speed. In the case of the X-rays and electrons which we have been handling in our experiment, we find that the greater the energy the larger the number of X-ray quanta required to be in equilibrium with the corresponding electrons, for quanta of large energy are transformed into electrons much more rarely than quanta of small energy, whereas electrons of large energy are transformed as often, and perhaps more often, than those of small energy. Thus the distribution of energy among the quanta is not the same as the distribution among the electrons; in the former there is a much larger number—relatively—of the quanta of larger energy.

The electrons which we are considering have very little power of penetration or of breaking away from the substances in which they are. At high temperatures, when they move more quickly, there is a considerable emission, an effect which has been much studied recently. But at ordinary temperatures the emission of electrons is small. Recently R. W. Wood has suggested that there must be an "aura" of electrons surrounding a conductor and extending a minute distance away, since only in this way can we account for the fact that electricity passes freely from one conductor to another when they are separated by a space of the order of a wave-length of light. But if the electrons have such difficulty in breaking away from a substance, this is not true of the X-ray quanta. If they behave like those we have been investigating of recent years, they have far greater powers of penetration than the electrons, and every body must be emitting them in streams. Moreover, if bodies be placed near each other, there will be an interchange which will hand energy from one to the other until there is an equilibrium. If a hot body is placed near a cold one, the former contains some electrons and corresponding quanta of great energy, and as these stream over to the cold body, they go through transformations which permit of loss of energy, since for a time they put the energy into electron carriers which can exchange, and do exchange, energies with others—through the mediation of the atoms, it may be. X-ray quanta have not that power of themselves. Thus in time the two bodies are brought to the same temperature.

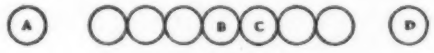


Fig. 10.

In this way we have a conception of radiation which on the surface differs from that which is ordinarily held. But does it do so really? May it be that we have merely found a different method of regarding the processes of radiation? If so, that would be a very good thing, for it is one of the best aids to inquiry to have more than one hypothesis which will link together a number of experimental facts. Nor need we be afraid if the hypotheses differ considerably. On the contrary, that means that we have the greater number of interesting things to discover between the two points of view and their final point of convergence.

Now we know that when light falls upon material substances there is an emission of electrons of slow speed; in other words, light radiation resembles

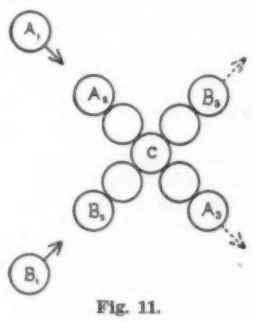


Fig. 11.

X-radiation in one important particular. Investigators have gone further. They have shown with considerable probability that the velocity of the ejected electron varies with the wave-length of the light; the shorter the wave-length, the swifter the electron. Moreover, there are lines of reasoning, worked out in great detail by Planck, Einstein, and others, which lead to the thought that light energy is contained in separate quanta; the shorter the wave-length, the more energy in the quantum. This is one of the most remarkable developments of modern physics.

It seems as if there were a strong invitation to consider radiation from this point of view. We ought not to think that in doing so we abandon the wave theory or its electro-magnetic development. Rather we might say that the radiation problem is too great to be seen all at once from any point to which we have hitherto attained, and that it is to our advantage to look at it from every side.

It would be quite fair, moreover, to say that there is something after all in the corpuscular theory of light. There is a very great deal of evidence, as I have already indicated briefly, for a corpuscular theory of X-rays; and it is widely held that the two forms of radiation are akin to each other. How can we hold a corpuscular and a wave theory of light at the same time?

If we say that radiation consists in the emission of quanta, each of which traverses space without spreading or altering in any way, and label this a corpuscular theory; and if, on the other hand, we suppose light to consist of wave-motions, and that we can resolve such wave-motions at any one time into elements each of which might exist alone and would then spread through space like a ripple on a pond; and if we say that the quantum in the one theory is to be matched with the element in the other, then, of course, the two theories are inconsistent.

But such inconsistencies are difficulties of our own making. If one hypothesis links together a number of observed facts, and a second hypothesis a somewhat different number; and if we think the two are inconsistent, the fault must be ours. We must be stretching one or other hypothesis to breaking-point, and we must work in the hope of finding a new hypothesis of greater compass. Until we do so, we are right to use those which are more limited; it is the way of scientific advance. So the great men of the past have done, as we may see readily.

Let us go back to the discussions of the close of the seventeenth century, the time when Newton, Huygens, Hooke, Pardie, and others debated the nature and form of light. A very important discovery had recently been made by Romer, who had shown by astronomical observations that light, which brought the news of the events taking place in space, took time to bring it; in other words, that light had a velocity. Romer had even succeeded in measuring the velocity with fair accuracy. Now Descartes had supposed the propagation of light to be instantaneous. He had considered it to be a pressure transmitted across a plenum between the luminous object and the eye; according to a well-known image, vision resembled the process by which objects are made manifest to a blind man, who feels for them with his stick and receives pressures transmitted thereby. Apart from the direct proof by Romer that this view was wrong, a very interesting objection to it is given by Huygens, who, after stating the Cartesian theory, remarks that "it is impossible so to understand what I have been saying about two persons mutually seeing one another's eyes, or how two torches can illuminate each other." That is to say, it is impossible to explain on a simple pressure theory the perfect facility with which rays of light traverse each other without injury. This mutual traverse of light rays interested Huygens exceedingly, and, as we shall see, influenced materially his choice of the hypothesis in terms of which he expressed the facts known to him.

Thus Newton and Huygens were led to introduce the idea of motion of some sort of matter as a fundamental point in their theories. They did so in different ways; and the distinction grew to be a cleavage between two schools of thought. It was not a very deep distinction at first; it would have been easy to have stepped from one side to the other of the dividing line. Only in later times did the corpuscular and wave theories stand

* Evening discourse delivered on September 6th before the British Association at Dundee, and published in *Nature*.

immovable in hostile antagonism. It is not at all impossible that modern research will once more draw the two theories together.

The difference may be put in this way: Newton imagined light corpuscles which moved in straight lines from the source of light to the recipient. He thought that the "light" had the same carrier from beginning to end of its path. We should now express his idea by saying that the "energy" of the light had the same carrier; but Newton did not, of course, conceive of light-energy as a quantity to be measured and discussed. How far he was from this more modern idea is instanced by his supposition that the radiating power of the sun was conserved by the mutual radiation of its parts.

On the other hand, Huygens imagined the light to be passed on from particle to particle of the æther; that is to say, the energy was not carried by one particle all the way, but by relays. It must be remembered that he thought of the æther as a collection of particles resembling the particles of luminous bodies, but of smaller dimensions. The latter particles he supposed to float in a subtle medium which agitated them and made them strike against the particles of the æther, which thus became the seat of spreading impulses. We might compare the difference between the ideas of Newton and Huygens with the difference between the dispatch of a message by a special runner and the spreading of a rumor.

Huygens has given two reasons for his choice of hypothesis: one, the extreme speed of light, which Romer had recently found; the other, the ease with which rays of light traverse each other. These induced him to reject the idea of the movement of matter through the whole of the distance from source to receiver, since he could not imagine how matter could move with so great a speed, nor could he conceive how material rays could pass through each other. He arranged æther corpuscles in a row between source and receiver, and supposed light to move along the row in the same way that a disturbance would move along a row of glass spheres placed so as to touch each other. Indeed, he filled all space with æther particles in contact so as to allow of the transmission of disturbances from any one point to any other. In such a plenum two disturbances might easily be imagined to cross each other without hindrance. To use an illustration which he gives himself, "If against this row (*B C* in Fig. 10) there are pushed from two opposite sides at the same time two similar spheres *A* and *D*, one will see each of them rebound with the same velocity which it had in striking; yet the whole row will remain in its place, although the movement has passed along its whole length twice over." It is, of course, the movements, not the spheres, which traverse each other. Or we may arrange the experiment as in Fig. 11. If the balls A_1 and B_1 are pushed in the directions of the arrows so as to strike the rows they are shown approaching, the spheres A_2 and B_2 will spring forward and continue the lines of motion of A_1 and B_1, and the movements will have crossed each other without any injury. He conceived such a result to be beyond explanation on a theory like Newton's.

His hypothesis met also, as he thought, the other of the two fundamental requirements. The disturbance might be supposed to move as fast as was desired, even with the extreme velocity which light, according to Romer, possessed. For, as he says, "there is nothing to hinder us from supposing the particles of the æther to be of a substance as nearly approaching to perfect hardness and possessing a springiness as prompt as we choose." And another very important property of light was illustrated at the same time, viz., that the velocity in free æther was independent of the intensity.

It is to be observed that Huygens takes the ideas of hardness and impenetrability of matter which he has drawn from the behavior of glass spheres and applies them to the molecules of the æther.

From what we have seen of the properties of the new rays we cannot allow Huygens any justification of the reasons which he gives for his preference for the wave theory. There were two, you remember. In the first place, he supposed that matter could not move with so great a speed as light; yet you see that the α particles move practically as fast as he conceived light to move, and they are as material as anything else. Secondly, he argued that streams of matter could not interpenetrate each other; yet we see that atoms can pass through each other easily. Indeed, the more we consider the behavior of the rays from radio-active substances, the more impossible appears the view that "particles" of any sort have boundaries which are limits to interpenetration. We see no reason for supposing that there is anything in the known universe which can retain a portion of space to its own exclusive use and forbid all strangers to enter therein.

So the reasons which Huygens gives for his choice of a hypothesis are both mistaken; and we might think that this was a bad begining for the structure which he built. But his true foundation was laid otherwise. The spreading-pulse theory suggested to him his famous construction of the wave front, which has been of such immense importance in the development of our knowledge of radiation. His construction gave a correct account of the phenomena of reflection and refraction, and, what was most wonderful, he found himself able to explain by its means the complicated motion of light in Iceland spar. In this way he began the marvelous development of the relations between light and crystalline structure which has roused the interest and admiration of the subsequent centuries. It is true that he had no idea of a regular succession of waves; in fact, he expressly states that he does not wish us to think of his pulses as following each other at regular distances. He did not explain colors, and he failed altogether to account for polarization. But his hypothesis linked certain facts together, and was useful so far as it went.

It was Newton with his corpuscular theory who introduced the idea of periodicity in order to explain the colors of the soap film and other "thin plates;" who ascribed differences in color to differences of frequency, and correctly described the phenomena of polarization as due to the rays of light having sides, a description which could not be applied to the conception of Huygens. Newton was able to express many of the facts known to him in terms of vibrations of an all-pervading æther; he saw that in such case the longer vibrations would excite the sensation of red, and the shorter—the more refrangible—the sensation of violet. He actually supposed that such vibrations traveled along the optic nerves and carried the sensations to the brain, and he directed attention to persistence of vision as evidence of the "vibratory nature of the motions at the bottom of the eye." Heat he supposed to be conveyed by æther vibrations. He could express the behavior of a soap film in respect to color in terms of the wave theory with formal correctness, showing its dependence on the ratio between the thickness of the film and the wave length of light. But he preferred to express his ideas on a corpuscular model, because he could not otherwise explain the formation of sharp shadows, and deemed it impossible for a pulse on rounding a corner to spread so little as light. It was for this reason he rejected the theory of Huygens, and he was perfectly right. If we take Huygens's own model, if we project a billiard ball against a group of other balls in contact, as we might, somewhat inefficiently, start a game of pyramids, the energy of motion is scattered every way, and balls fly in all directions. Huygens never met this objection; it was not answered until the time of Fresnel, more than a hundred years afterward. Newton was also impressed with the impossibility of varying the nature of light by transmission, reflection, or refraction, and ascribed all apparent changes of color to sorting processes. As he says, "very small bodies conserve their properties unchanged in passing through several mediums, which is a condition of the rays of light." He was thinking of contemporaries who supposed that the color of light was readily changed in deviation or transmission.

The essence of Newton's idea was the travel of light as an entity which did not spread or change as it went. He implied by the term "corporeity of light" no more than "something or other propagated every way in straight lines from luminous bodies without determining what that thing is, whether a confused mixture of difform qualities or modes of bodies, or of bodies themselves; or of any virtues, powers, or beings whatsoever." He strongly opposed a tendency to read more into his hypothesis than it was intended to hold. In these respects the X-ray resembles very closely the corpuscle which Newton conceived, so long at least as it remains untransformed. But if transformation occurs the electron generally loses energy, and a retransformed X-ray will have less energy than the original, a well-known process. It may be compared with the phenomenon of fluorescence, of which Newton knew nothing.

Now if X-rays are to be classed with light, as there are reasons for supposing, and as many do suppose with more or less conviction, then it must be acknowledged that Newton's conception has more value in it than the last century has been accustomed to grant. But we shall not therefore adopt Newton's theory as he left it. It is too obviously defective. It cannot explain diffraction, and his main reason for rejecting the wave theory was wrong. He gave no satisfactory explanation of the uniformity of the velocity of light in space. Even his explanation of the colors of thin films is defective. Moreover, he was hopelessly at sea, and, it may be observed, so was Huygens, in attempting to explain the absorption of light. Neither of them had at his command any mechanism, but that of the collisions between particles of æther, particles of matter, and light corpuscles, and they could but juggle with the relative sizes of these things. Newton was very hard put to it to explain the difference between a perfectly transparent body and a perfectly black one, and was compelled to suppose it due to a small difference in the sizes of the particles of matter. Huygens would have liked to ascribe internal reflections at the surface of a piece of glass to collisions between the æther corpuscles and the particles of air outside, and was disconcerted by the fact that reflection took place equally well when there was no air at all. But it is quite unnecessary to follow the subject further, and discuss the contributions of Young and Fresnel, and the other men of famous names to whom the modern theories of radiation are due.

The point is simply this, that each of these great workers constructed for himself a hypothesis or model, which represented correctly certain facts known to him, and by its aid was able to use what he knew as a means to learn more. The results of his work depended upon the construction of his model, and his choice of the known facts he had made it to represent to a greater or less degree. For no one could construct a hypothesis which represented correctly all that was known. But if it was correct so far as it went it led to good results in a limited field.

Therefore it happens that hypotheses must always be diversified, and it is well for the possibilities of advance that they should be. If now we have a number of new facts regarding new radiations, if it turns out that they are to be carried over to the older radiations which have been studied for so long, and if the wave theory cannot absorb them at once, this means no rejection of the work of the past, no retracing of steps. It means rather the enriching of our opportunities of advance, in which all the good work which has been done in the past will tell as well as that which we may hope to do in the future.

If my observations are well-worn sayings, you will perhaps forgive the fact in the newness, and I should like to add, if I might, the appropriateness, of the illustration. It does, after all, make for our encouragement and efficiency if we remember that we are free to make any hypothesis we please, and that we are not to be judged directly for the choice we make, but indirectly for the use we make of it. Our reasons for choosing a scientific creed will probably be wrong; we cannot hope to do better always than Newton and Huygens. But perhaps we can do something with it which will be good and will last. It may contribute also to the general peace if we remember that our hypotheses are made, in the first instance, for our own personal use, and that we have no justification for demanding that others shall adopt the means which we find most convenient in the modeling of our own ideas.

International Engineering Congress, 1915

In connection with the Panama-Pacific International Exposition which will be held in San Francisco in 1915, there will be an International Engineering Congress, in which engineers throughout the world will be invited to participate.

The congress is to be conducted under the auspices of the following five National Engineering Societies: American Society of Civil Engineers, American Institute of Mining Engineers, the American Society of Mechanical Engineers, American Institute of Electrical Engineers, and the Society of Naval Architects and Marine Engineers.

These societies, acting in co-operation, have appointed a permanent Committee of Management, consisting of the presidents and secretaries of each of these societies, and eighteen members resident in San Francisco.

The committee has effected a permanent organization, with Prof. William F. Durand as chairman, and W. A. Cattell as secretary-treasurer, and has established executive officers in the Foxcroft Building, 68 Post Street, San Francisco.

The ten members of the committee, consisting of the presidents and secretaries of the five national societies, will constitute a committee on participation, through whom all invitations to participate in the congress will be issued to governments, engineering societies, and individuals.

The papers presented at the congress will naturally be divided into groups or sections. During the congress each section will hold independent sessions, which will be presided over by a chairman eminent in the branches of engineering covered by his section.

The scope of the congress has not as yet been definitely determined, but it is hoped to make it widely representative of the best engineering practice throughout the world, and it is intended that the papers, discussions and proceedings shall constitute an adequate review of the progress made during the past decade but an authoritative presentation of the latest developments and most approved practices in the various branches of engineering work.

Fig. 1.—Floor Test—Applying Water.

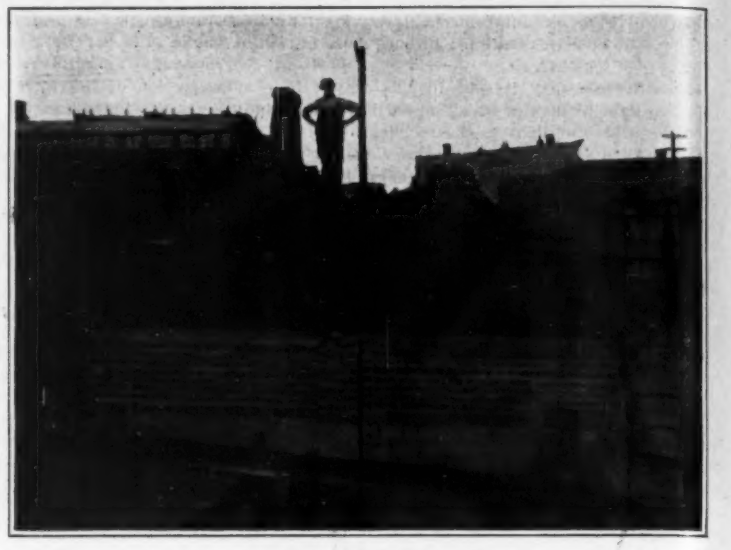


Fig. 2.—Floor Test—Final Load.

Fireproof Construction*

Testing Materials for Their Power of Resisting Extreme Temperatures

By Harold Perrine†

THE existing Building Code of the city of New York defines a fireproof building to be one constructed with walls of brick, stone, Portland cement concrete, iron, or steel, in which no wood beams or lintels shall be placed, and in which the floors shall be constructed with wrought-iron or steel floor beams. Between the beams are set brick arches, hollow-tile arches, reinforced Portland cement concrete segmental arches, or slabs of various materials and types. If the structure is not over 12 stories or 150 feet in height, inflammable flooring and trim are allowed, but if it exceeds this height, the floor surfaces are of stone, cement, rock asphalt, tiling, etc., or the sleepers and floors are of wood treated to render it fireproof. Outside window frames are of metal or metal-covered wood; inside sashes and trim are of treated wood, and all partitions are of fireproof material. Exposed metal is always encased by a protective coat.

The term "fireproof," as applied to this entire class of buildings, is often erroneous. Few present forms of construction are strictly fireproof; some, however, have more and greater "fire-resisting" qualities than others. It is the duty of certain authorities in each large community to determine what systems possess these qualities, and to how great an extent, in order to minimize the loss of life and property in case of fire. In the several boroughs of the city of New York the regulation of these matters falls under the jurisdiction of the respective Building Bureaus, this regulation being effected by constant tests and inspection. The methods of conducting these tests will be described in this article.

Two main classes into which fire tests are divided are: (1) those conducted upon full-size construction; (2) those upon samples. These are subdivided again as follows:

Full-size tests:

1. Floor construction.
2. Partition construction.
3. Doors, windows, etc.

Sample tests:

4. Flooring materials.
5. Moving-picture booth construction.

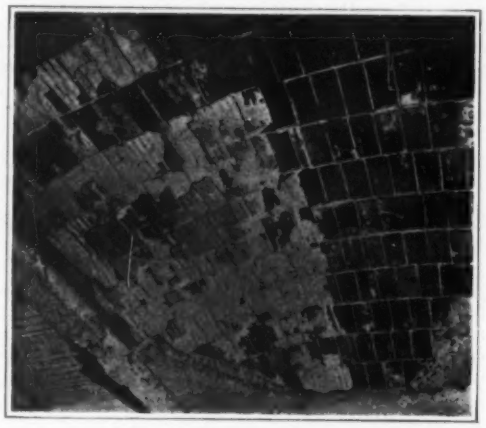


Fig. 3.—Tile Dome, After Test.

6. Building materials, used as substitutes for brick, i. e., cast stone, etc.
7. Fireproofed wood.

Full-size tests are, in the main, conducted in structures designed and built for that express purpose. Sample tests, on the other hand, may be conducted in any laboratory equipped with common standard apparatus, gas furnaces, torches, pyrometers, etc.

The methods described in this article are, in every case, those prescribed by the Building Code, and employed at the Columbia Fire Testing Station, Greenpoint, Brooklyn, New York, and in the Materials Testing Laboratories of Columbia University.

TESTS OF FLOOR CONSTRUCTION.

The system to be tested forms the roof of the test house, which structure is essentially a cinder-concrete oven of permanent construction. Properly supported upon piers 2½ feet from the ground is a grate composed of railroad rails and wire mesh, about 250 square feet in area. The vertical distance from the grate to the roof is about 9½ feet. The floor system to be tested is supported by steel I-beams resting on the tops of the walls, spaced at distances suitable to the span or spans under test, and having a clear span themselves of about 14 feet. Ample draft openings and flues are provided to facilitate the control of the fire, their location being readily seen in Fig. 11.

The purpose of the test is to determine the effect of a continuous fire below the floor lasting four hours, at an average temperature of 1,700 deg. Fahr., a temperature generally conceded to be that of a burning building, the floor carrying at the same time a distributed load of 150 pounds per square foot. At the end of the four hours the under side of the floor, while still red hot, is subjected to a 1½-inch stream of cold water through a hose at short range, under a 60-pound pressure, for 5 minutes; the upper side of the floor is then flooded with water at low pressure, and afterward the stream is applied at full pressure to the under side for 5 minutes longer. Deflections of beams and floor are measured continuously during the test. On the following day, when the floor is cool, the load is increased to 600 pounds per square foot.

Several cords of dried mixed pine and hardwood, kindled with shavings and kerosene oil, is the fuel used, the frequency of firing depending on the recorded temperatures. Water pressures are controlled by an engine furnished through the courtesy of the fire department. Temperatures are read from a Siemens-Halske galvanometer, to which are attached three thermo-

Fig. 4.—Laboratory Test of Splinters of Veneer.

Fig. 5.—Laboratory Timber Test.

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† In charge of the Columbia Fire Testing Station. The photographs with this article were supplied through the courtesy of J. Boldtman, School of Mines, Columbia University.

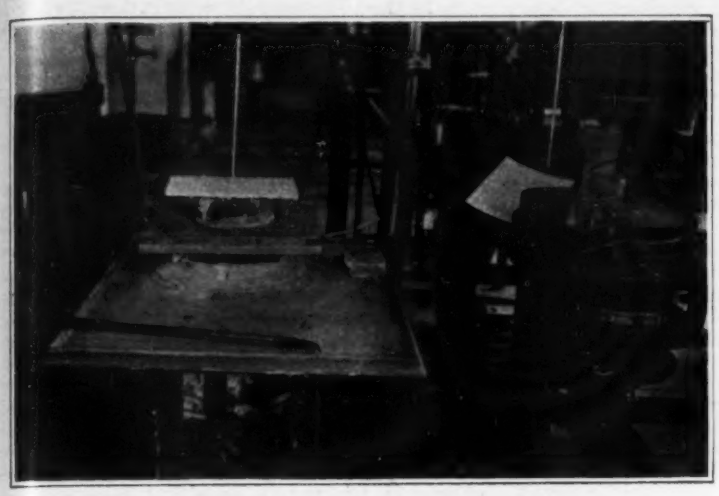

Fig. 6.—Laboratory Test of Flooring Material.

Fig. 7.—Laboratory Test of Shavings.

electric couples at the ends of insulated wire leads. These couples, protected by proper tubing, are inserted through the floor, so that they extend about 6 inches below its lower surface. The leads will be noticed in Fig. 11. Deflections are read by Y level, from an elevated position, upon vertical rods placed at various points on the floor. Loading is effected by means of pig iron applied in segregated piles, to insure uniformity, and to eliminate arching.

To pass the above test successfully, no flame must penetrate the floor, no part of the load shall have fallen through, and the beams must have been protected from the effects of fire and water, so as not to have been deflected more than 2½ inches. Fig. 1 illustrates the method of applying water to the under side of a floor system. The stream is first directed over the grate itself, extinguishing the fire, and is then pointed upward and played upon the test covering, but in a manner so as not to act continuously in one spot. Fig. 3 shows the condition, after test, of a terra-cotta tile arch, or dome. The right-hand portion is in excellent condition. This was due mainly to the fact that this section, before the fire, was coated with plaster, while the left-hand portion was not so protected. Projecting through the arch at three points may be noticed the ends of the tubes in which were inserted, from above, the thremocouples for recording temperatures.

Fig. 8.—Partition Test—During Fire.

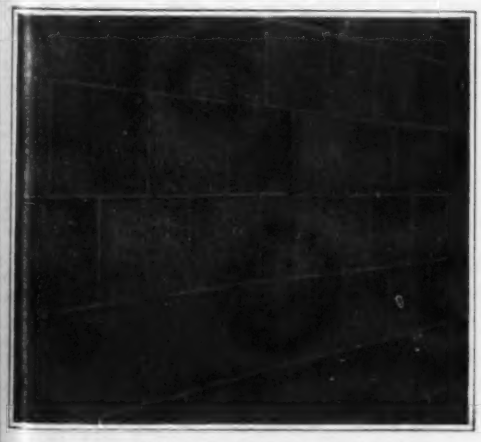

Fig. 10.—Partition Test—Result Satisfactory.

TESTS OF PARTITION CONSTRUCTION.

The structure in which partition walls are tested is 14½ feet long, 9½ feet wide and 9½ feet high. The side walls form the only parts under test, each being 138 square feet in area; the end walls and roof are of permanent cinder-concrete construction. This chamber is supported by foundation walls upon which also rests a grate. Draft openings are provided below this grate, as well as suitable chimneys leading from the top of the house.

The partition, or shaft construction, is subjected to a continuous heat from a wood fire for at least one hour. An average temperature of at least 1,700 deg. Fahr. is maintained during the second half-hour. At the end of an hour's fire each wall is subjected to a stream of water on the inside, through a fire hose with a 1⅛-inch nozzle, at 30-pound pressure for a period of 2½ minutes.

As in the previously mentioned test, the firing is done with dry cordwood. All things considered, this is probably the best and most satisfactory fuel to use in these two tests. Gas or oil may be used, and is employed in some plants, but the wood fire certainly duplicates more nearly the conditions present in an actual fire, and is much more easily obtainable. Hydrant pressure should be ample for this test, and an engine is never necessary.

The temperature of the oven is observed by a Siemens-Halske galvanometer, to which are attached three couples. One of these is inserted through each partition (Fig. 8), projecting about 6 inches into the fire; the third is suspended through the roof. Inward and outward deflections of the walls are measured with reference to a wire stretched horizontally, near and parallel to the middle of their respective faces. Heat conducted through the partition is observed by a thermometer, insulated from radiating heat by a wooden box, its bare mercury bulb being in actual contact with the outside of the partition. (See Fig. 8).

A test of this character is considered successful when neither fire, smoke nor water passes through any part of the wall, nor is it bulged or otherwise deformed to the extent of rendering it unsafe. Fig. 10 shows the excellent condition of the inside of a 3-inch cinder-concrete block partition, after having passed the above test. Fig. 9 shows a typical failure of an insufficiently protected sheet-metal wall construction. Note the warping of the metal caused by expansion and also the total absence of plaster on the major portion.

Fig. 11.—Floor Test—During Fire.

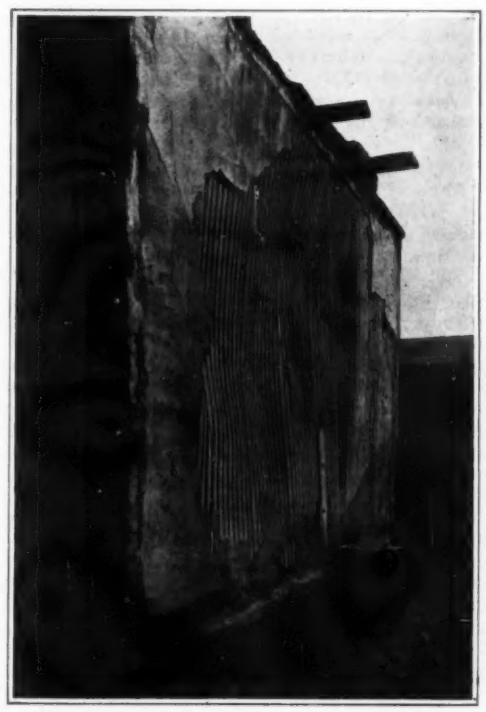

Fig. 9.—Partition Test—Result Failure.

TESTS OF WINDOWS, DOORS, ETC.

Tests upon this class of construction, together with those upon various forms of roofing, while essential

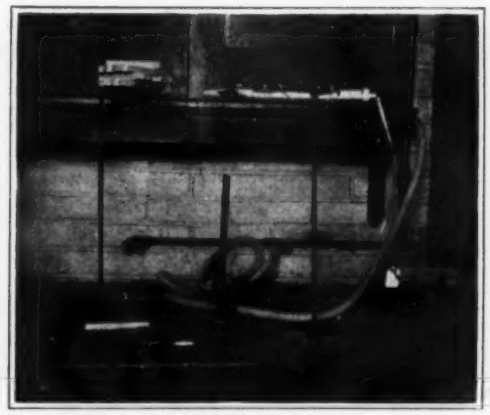

Fig. 12.—Laboratory Crib Test.

to their acceptance for use in fireproof buildings in New York city, are not conducted in exactly the same manner as are all the other tests described in this paper.

The Underwriters' Laboratories at Chicago maintain equipment for testing the fire-resistance of many forms of protection devices. Their work is under the supervision of the National Board of Fire Underwriters. Reports of tests of different articles conducted in these laboratories are submitted to a council which designates their classification. The articles are then labeled in accordance with the findings of the council. The labels represent the quality of the material as a fire-protection and are a safeguard to the consumer.

Owing to the rigid methods of inspection practiced by the Underwriters, a duplication would be superfluous and consequently the approval of this body often will insure the acceptance of the article in question by the New York Building Bureaus, within the limits of the code. Since this paper deals with tests falling immediately under the direction of the city authorities, tests of windows, doors, etc., will not be described. The requirements for a fireproof door are, however, quite similar to those for a partition wall.

FLOORING MATERIALS—SAMPLE TEST.

A composition flooring material to be used in a building of 150 feet in height must be subjected to the following test: A sample of the material 12 inches square and of the thickness to be used in service is laid face down upon two cast-iron supports, 1 inch thick, which are lying across the opening of an 8-inch gas and air crucible furnace. Directly beneath the sample, and exposed to the flame from the furnace, is inserted a thermo-couple incased in a quartz or porcelain tube, and connected by leads to a pyrometer. Against the center of the back of the sample is placed a mercury thermometer in actual contact, but protected by proper means from circulating air currents. The temperature of the furnace is raised gradually from that of the room to 1,700 deg. Fahr. in 20 minutes and then maintained at that point for 10 minutes longer. At the expiration of that time the sample is removed from the furnace and a stream of cold water, at about 60-pound pressure, is directed against its face for one minute.

To pass this test successfully, the flooring should not warp to a great extent, nor should it crack across, burn, or be softened to a depth of more than half its thickness.

Fig. 6 shows the apparatus used at Columbia University to conduct this test. A sample may be seen resting over the crucible, the thermometer for noting the conducted heat is placed above it, and the pyrometric outfit is in position for easy control of temperature.

MOVING-PICTURE BOOTH CONSTRUCTION.

A partition wall which has satisfied the requirements of the full-size partition test, described above, is acceptable as an inclosure for moving-picture apparatus. Also, "any other material such as asbestos board used as a covering for the angle-iron framework . . . must be at least ¼ inch thick, and must comply with the following tests and requirements for fire-resisting qualities." The test consists of essentially the same procedure as in the above-described flooring test.

BUILDING MATERIAL USED AS SUBSTITUTE FOR BRICKS.

Material in the form of bricks, artificial stone, etc., before being used within the city limits, is subjected to a series of tests, including transverse and compressive strength, absorption, freezing and fire.

The last test is run upon two samples. These are placed in a cold gas furnace, in the form of an oven, the temperature then being raised to 1,700 deg. Fahr. in one hour. One of the samples is then plunged, red hot, into cold water and results noted. The second sample is allowed to cool slowly in air at room temperature. The material should not disintegrate under this treatment.

FIREPROOFED WOOD.

The above term is applied to flooring and interior trim which has been treated by chemical impregnation to render it fire-retardant. It is, in fact, inflammable, if subjected to a hot flame for a sufficient time. But, when properly prepared, it will burn slowly in contact with the fire, but, on removal, will not support combustion, even to the extent of glowing, for more than a few seconds.

Every 2,000 feet of this material is sampled. These specimens are inspected as follows, to prove their fire-resisting qualities. At present, three tests are conducted upon pieces cut from each of the above samples, viz.: (1) Timber test; (2) Crib test; (3) Shavings test.

Timber Test.—From each of the submitted samples is cut a piece 12 by 1½ by ¾ inches. This piece is planed to exact size and measured accurately to 0.01 inch. Such samples are then subjected in pairs to a vigorous flame from a gas crucible furnace for 2 minutes, at a temperature of 1,700 deg. Fahr. They are then taken from the fire and the duration of flame and glow noted. The samples are then sawn in two, and the area of the least cross section measured by planimeter. Specifications for acceptance require a flame and glow of not more than 15 and 20 seconds, respectively, and a percentage unburned area of 45 for soft wood and 55 for hard wood. (Fig. 5).

Crib Test.—Cribs are built up in four tiers of sticks ½ by ½ by 4 inches upon a chemists' ring stand, and subjected to an 18-inch flame from a gas torch at an approximate temperature of 1,200 deg. Fahr. Combustion, as evidenced by flaming, must be supported not longer than 20 seconds nor, as evidenced by glowing, for more than 30 seconds. (Fig. 12).

Shavings Test.—Thin shavings, taken from each of the above samples, are placed, in a 2-inch layer, on the wire-mesh bottom of a tin pan 1 foot in diameter. A common bunsen burner, giving a yellow flame, is placed beneath the mesh for 25 seconds. The shavings must not be consumed in less than 5 minutes, nor must the flame reach higher than 6 inches. (Fig. 7).

Each sample of timber, representing as it does 2,000 feet of lumber, must pass satisfactorily two of the above three tests.

Veneer Tests.—Most veneers are obviously much too thin to permit of the use of the timber test. A test in use in the Columbia Laboratories, designed to meet this difficulty, consists of placing a small quantity of "splinters" upon a red-hot plate, maintained at about 1,000 deg. Fahr. for 1 minute. (Fig. 4). To pass successfully, none of the splinters must flame in less than 40 seconds. A crib test, similar to the regulation one previously described, is also conducted upon veneers.

RESUME.

The above regulations for testing various forms of construction for fire resistance are based upon the observations and experience of many investigators. Prof. Ira H. Woolson, formerly of the Department of Civil Engineering, Columbia University, devised and perfected several of the above tests, and was one of the pioneers, in this country, in this type of inspection. Sources from which results may be obtained are now so numerous as to facilitate to a marked degree the arrival at proper conclusions. One fact is worthy of note in this regard: Re-enforced stone concrete floor systems are now accepted, without test, as are also concrete building blocks, provided, of course, that they meet other requirements as to strength, etc. This marks an advance in our knowledge of the behavior of stone concrete in service, and denotes a feeling of confidence that the floor fire-test as now conducted affords ample protection. In fact, the American Society for Testing Materials has adopted it as a standard.

The same cannot be said of the full-size partition test. It seems to be generally conceded that the duration of the application of fire is about one half what it should be, to insure the rejection of walls which will afford insufficient protection. The society mentioned above, through its Committee on Fireproofing Materials, recommends a two-hour duration of fire for the completion of this text.

There are several possible improvements in the methods of handling laboratory specimens. The tests on moving-picture booth and flooring materials prove quite satisfactory as a rule, giving definite and conclusive results. The reverse is true in regard to the oven test on substitutes for brick. To specify that the specimens must not disintegrate is rather indefinite. Complete absence of disintegration is almost impossible, considering the severity of the action of fire and water, while interpretation of the specifications to their exact letter is difficult. A definite means of inspection should be provided; for example, some form of test to ascertain the deterioration in strength after treatment would be advisable.

In regard to fireproofed wood, several profitable changes might consistently be made. The timber and crib tests probably should be retained, with slight variations, but the test on shavings should be omitted. It is extremely difficult to obtain shavings exactly duplicating one another, and, finally, any slight variation of draft conditions, height of flame, etc., vitally affects the results.

Accident Prevention in Construction Work*

A Somewhat Neglected Field in the Movement for Industrial Safety

An encouraging and rapidly increasing amount of attention is being devoted to accident prevention in factories, but construction work has been comparatively neglected in this respect. We therefore present a few suggestions along this line, below. Most of them will be found to be familiar and commonplace, but their observance is nevertheless highly important. Many of them are included in local building ordinances, but this, unfortunately, does not prove that they are always followed in practice.

A builder who looks over the suggestions here made, and dismisses them from consideration merely because they do not contain anything especially novel, makes a great mistake; for a large proportion of the accidents that occur in construction work are due to the neglect of these very precautions. The list has been compiled as the result of an extensive experience, and there is nothing in the least degree visionary or imaginative about it.

DEMOLISHING BUILDINGS.

Old buildings should be taken down story by story, so that high walls and other dangerous parts may not be left towering above the workmen. Nothing should be thrown from the upper floors, unless watchmen are stationed below to see that nobody can come within the zone of danger. Chutes should be provided, invariably, for the removal of brick and other loose material of similar character, and they should be covered on all four sides, so that anything once placed in them must go through to the bottom, and have no chance to jump out. Walls of brick or stone that are at all thin should be taken down by the aid of scaffolds—horse-scaffolds being convenient for this purpose if the work is done from the inside of the building. The beams of floors upon which work is being done should be kept tightly covered with boards or planks, so that materials or tools cannot pass through them; and no masses of material should be allowed to fall upon the floors from any sensible height. Stair railings should be left in position as long as possible. Old materials and rubbish should not be allowed to accumulate on the floors, but should be removed as fast as the work of demolition proceeds.

STEEL WORK.

The men who erect the steel skeletons of our modern high buildings are necessarily courageous and self-reliant, and their lives often depend upon the quickness of their perceptions, and upon the coolness and certainty of their decisions and their movements. In the later riveting operations, the steel man is amenable to all such reasonable recommendations as may apply to scaffold workers in general; but in the earlier part, when the steel members are being swung into position and bolted there, he is almost a law unto himself. His task at this stage is often more hazardous than that of the steeple-jack; because by the use of various appropriate safety devices the steeple-jack, if he will, can guard himself fairly well against falling, while the structural steel man has to do his work mainly without any of these auxiliary aids. For example, he can seldom use a life-line with advantage in the early stages of the job, because he has to move about freely and almost continuously. There are times, indeed, when a life-line might be distinctly dangerous to him, by impeding his movements in critical situations.

For avoiding accidents in placing beams and other members of the framework, we have to depend chiefly upon general considerations, rather than upon specific and definite rules. The main thing is to employ none but careful, steady, experienced men, upon whom implicit reliance can be placed; and no man should be permitted to engage in this kind of work unless he is temperate, cool-headed, strong, spry, active, and in perfect health.

One of the cardinal principles in the management of these steel workers is to prevent them, absolutely and unqualifiedly, from exposing themselves to *unnecessary* danger. They will often do this, either from real indifference or for the apparent purpose of impressing their fellow-workers; but such acts should be firmly reproved, and dismissal should be the certain penalty of repeated willful behavior of this kind.

The men should never be permitted to engage in purely spectacular performances, nor to ride up with beams or other materials, nor to slide down upon the hoist ropes, nor to take any kind of a chance whatsoever, for the sake of merely saving a little time or trouble. They should never be permitted to work during high winds, nor when the beams are slippery from

* Copyright, 1913, by the Travelers' Insurance Company.

ve or frost; and however important the progress of the work may appear to be, the steel men should never be allowed to work in exposed places more than a reasonable number of hours, nor to become unduly fatigued.

COVERING FLOORS.

All the permanent openings in the floors should be either planked over, or substantially guarded with rails or fences; and the removal of planks that have been laid down to cover up openings should be absolutely prevented. The workmen on a construction job usually have but little regard for this rule, and they often remove the planks and put them to other uses, as soon as the safety-inspector goes to another floor. They do this, not maliciously, but merely because they do not understand the paramount importance of keeping the openings covered over.

The floor arches should be kept within two stories of the derricks, whenever practicable; and where this is not practicable, the floors should be temporarily covered with a substantial layer of planking. It is especially important that the floors on which the derricks stand should always be planked over solidly, because men are traveling about upon these floors constantly, and tools and materials are especially likely to be dropped from them upon the other workmen below. In planking a floor, no matter for how short a time, special care should be taken to see that none of the planks are placed so that they can be tipped by stepping upon their ends. Planks so set are often called "traps," and the name is well chosen. Many an unfortunate man meets his death from them, or is severely injured.

SCAFFOLDS.

It is notorious that pole scaffolds are often built of utterly unsuitable material, and that they are erected in defiance of constructive principles that would be considered supremely important in a permanent structure. If the reader will critically examine the pole scaffolds that he sees during (say) the next month, he will find, everywhere, that there is room for tremendous improvement in them. Great care should be given to their design and construction, and a plentiful amount of first-class lumber should be used in erecting them.

As a rule, the swinging scaffolds that are used for laying brick, and which are supported by steel cables from the framework of the building, are much safer than the pole scaffold; but they should be inspected, thoroughly and carefully, every time they are used, and nothing should be taken for granted about them. Every bolt and nut should be examined, and the cables and their fastenings should be inspected with special care. The scaffolds used by bricklayers should always be provided with hand-rails, and every such scaffold should also have a toe-board, to prevent materials or tools from falling over the edge of the platform. Wire-mesh side screens are recommended for all bricklayers' scaffolds. Many builders consider that they are not practicable for pole scaffolds or horse scaffolds, but they could certainly be used on the suspended form. Whenever scaffolds are located so that there is quite a height over them, from which materials or tools might be dropped, they should be provided, in addition, with an efficient overhead protection of wire netting, or of some effective substitute. It is common indeed to see the hand-rails, toe-boards, side screens, and overhead protection entirely omitted from scaffolds, and many of the scaffold accidents that occur are due to these omissions.

The planks forming the platforms of scaffolds should be laid tightly together, so that there will be no chance for small tools or materials to fall down between them. The light swinging scaffolds that are used for painting should be lashed at all times, so that they cannot swing materially in any direction. This is especially important when leaving the work for the night. All tools and materials should likewise be removed from these light scaffolds when the men are not at work upon them.

Men should preferably be kept away from places immediately under scaffolds, whether these are outside of the building or inside; and when this cannot be done, a substantial shed should be erected, so that the men below will not be injured in case of the fall of tools or materials. Sidewalk sheds should be stout, solid, and wide, and they should have high screens of wire mesh at their outer edges. If the building is unusually high, broad and substantial secondary protective platforms of planking should be built out from it at various heights, to catch any bricks and implements that may fall. On the Woolworth Building, in New York city, four such auxiliary platforms were used, each about twenty feet wide. The debris that collects upon these protective platforms proves their value, for it would have fallen farther if they had been absent, and it might have killed or badly injured workmen or persons in the street.

For some strange reason it is customary to build the office of the head contractor, on the sidewalk bridge, in such a place that it is pretty likely to be struck by stones or by other objects that may fall to the bridge. Convenience requires that the office be near the work, but there is often a great difference in the exposure, according as it is built at one part of the sidewalk bridge or at some other part.

Doorways and passageways, where men have to pass under a scaffold or under some other place where construction work is going on, should be effectively covered with roofs or sheds. Mortar beds are often placed almost immediately under the scaffolds. If they cannot be placed elsewhere, they should be protected by substantial roofs.

HOISTS.

All hoist openings should be solidly fenced in, and the entrances to them should be protected by gates of ample height, which should always be kept in position. Bars are often used to protect shaft openings, but they do not give sufficient protection, and they are often even dangerous. The men should never be allowed to stand or ride on the material hoists. Contractors and foremen should also keep away from these hoists, because it is easy to set a bad example to the laborers and others, who cannot see any sufficient reason why they should not ride, if their superiors consider it safe to do so.

If special passenger hoists are used, the maximum number of persons that may safely ride upon them should be specified in each case, and no greater number than this specified limit should be permitted to step into the cage, under any circumstances.

The guide-rails of the hoists should be kept rigid and in correct position at all times. This is a point to which proper attention is seldom given, and yet it is most important. All hoists should be inspected at frequent intervals by qualified elevator experts, and any defects that are found should be promptly remedied. In particular, the cables should be renewed whenever they become worn or frayed or partially broken, and care should be taken not to run the cable of any kind of a hoisting apparatus over blocks or pulleys that are too small to be appropriate to the size or quality of the cable that is used. All hoist cages should have solid sides at least six feet high, except on the entrance side, and should be covered overhead, to prevent accidents from falling objects, and every hoist should be provided with an effective safety device which will prevent the cage from falling in case the cable or any other essential part of the mechanism should break.

Heavy and massive materials, such as beams and building stones, should be hoisted outside of the building whenever this is feasible, and never through shafts or stairways.

Derricks should be abundantly strong to support the heaviest loads that may be thrown upon them, and they should be provided with ratchets and pawls, and also with effective brake mechanisms, so that they can be checked with certainty, and can be lowered slowly and safely even when under the necessity of supporting their full loads.

It is important, in connection with hoisting, to have a signaling system that will be positive and reliable, under all circumstances. The usual system, in which the signals are given by sounding either one or two strokes on the engineer's bell, may be replaced with advantage by the more modern one of using three different signals; two strokes of the bell signifying to hoist, three strokes to lower, and one to stop. This code has the advantage of being perfectly definite. It also avoids the danger of giving a starting signal by the accidental fouling of the signal rope, since one stroke of the bell, on this system, has no meaning to the engineer when the load is stationary.

We may also direct attention to the electric method of signaling that was recently tried out on the Municipal Building in New York city.

MISCELLANEOUS SUGGESTIONS.

The miscellaneous points that might be profitably mentioned are so numerous that it is hard to make an intelligent selection. The light should be good throughout the building, and the floors should also be kept as clean as practicable. It is especially important to keep the gangways and passageways clear, and free from obstructions of any kind. Warning signs should be put up at all dangerous points, temporary hand rails should be provided for the stairways, and temporary wooden treads should be fitted to the steps of the stairs to give secure footing. Screens should be erected wherever required, for the protection of the public, and loose, light material should be kept off the roof, especially when high winds are prevailing. Men cutting concrete or other similar materials should be obliged to use chisels that are provided with handles, in order to avoid injury in case the striker misses the head of the chisel. One of the commonest mistakes about building operations is to leave nails and other sharp points projecting from the woodwork, or from boards and planks that are lying about under foot. All such nails and points should be carefully removed, or rendered harmless in other ways, because they can produce very ugly and dangerous wounds.

EDUCATION.

The men who superintend the erection of our big buildings know pretty well how the work ought to be conducted in order to lessen the number of accidents, but there is great need of educating them so that they will do the things that they know ought to be done. Every superintendent and every foreman, for example, should be made to believe, absolutely and unqualifiedly, in the various suggestions offered above, and he should adopt them as prime essentials in his professional faith; and a similarly thorough education in this respect is needed, fully as much, and perhaps even more, by the workmen also.

TRAVELERS INSPECTIONS.

There is great need of intelligent and thorough inspection in connection with building operations, and the service should be frequent, because the conditions that prevail in such work change quite rapidly. It is reasonable to suppose that the best inspection service can be had through the individual or corporation that has the greatest money interest at stake, and therefore the greatest material incentive to thoroughness and efficiency. The contractor no doubt has a big interest in the matter, from the standpoint of his pocketbook as well as from general humane considerations; but he has many other things to think of at the same time, and he can hardly give to the safety problem the minute attention that it must receive, if accidents are to be prevented or effectually reduced. The liability insurance company is really the most logical source from which efficient inspections may be expected, and if it is alive to its possibilities and responsibilities it will maintain an inspection force that is competent to deal with the accident problem in an intelligent and effective manner.

Chemical Treatment of Waste Wood*

Recovering Values from Low-grade Material

By H. K. Benson, Professor of Industrial Chemistry in the University of Washington, Seattle, Washington

the states comprising the Pacific Northwest of the ited States the extent of the land from which the ts have been removed is measured in millions of s. In the western half of the State of Washington e the logged off or cut over land comprises approxiely three million acres. Upon this land there still ains for the most part a dense and tangled mass of e from the logging operations consisting of stumps, tree tops, branches, rejected logs and underbrush. To remove this *débris* and clear the land so that it may be used for agriculture requires an outlay of labor and power which, when measured in money, is equivalent to not less than $100 and frequently as much as $200 per acre.

In view of these facts it has seemed reasonable to many that an attempt should be made to utilize this waste by subjecting it to proper methods of treatment, so as to yield marketable commodities and thus render some compensation to those engaged in clearing, thereby lessening the cost of the agricultural lands of the wooded portions of the Pacific Northwest. With this end in view a number of investigations have been carried on by the writer in co-operation with the Federal bureaus and with commercial organizations, and an attempt will be made in this paper to present a review of the work which has been under way during the past three years. This may be conveniently grouped under the heads of: (1) Steam distillation products; (2) Destructive distillation products; and (3) Hydrolyzed or fermentation products.

*Paper read before the Eighth International Congress of Applied Chemistry.

Sawmill Equipped With Steam Distillation Plant for the Treatment of Waste Material and the Recovery of By-products.

Scene in a Douglas Spruce Forest Following a Fire. Much of the Remaining Timber Still Contains Valuable Constituents.

I. Steam Distillation Products.

The work has thus far been largely restricted to the waste wood resulting from the logging of Douglas-fir (*Pseudotsuga taxifolia*)[1] and comprises the products obtained by distilling fir stumps in one experiment and fir boughs containing the needles in the other experiment.

For the distillation of fir stumps one of the commercial plants was utilized. A representative sample of wood was transported to the plant and there reduced by means of a wood chipper or "hogging" machine to small chips. Four thousand pounds of these chips were loaded into a retort and steam distilled for a period of four hours, the steam being obtained from boilers operating under a pressure of fifty pounds.

The yield of oil obtained in this experiment was five and one fourth (5¼) gallons. It had a straw yellow color with a specific gravity at 15.5 deg. Cent. of 0.8799 and a viscosity (Engler method) of 1.13. When redistilled with saturated steam it yielded eighty per cent of water-white distillate, the residue consisting of a heavy yellow oil with a characteristic but pleasant resinous odor. The name "Oil of Douglas Fir" has been tentatively assigned to this residue.

The water-white distillate was next examined by the methods prescribed in Bulletin 109, revised, Bureau of Chemistry, United States Department of Agriculture, and the following constants determined:

Specific gravity at 15.5 deg. C	0.8676
Distillation—Initial boiling point is 156 deg. C. and 95 per cent distills between 156 deg. and 165 deg. C.	
Residue on evaporation	1.115 grammes
Refractive index at 15.5 deg. C	1.4718
" " " 20 deg. C	1.4696
Polymerization	less than 0.1 cubic centimeter
Flash point	46 deg. C.
Spot test	no stain
Rotation (∝) 20 deg. C	25 deg. laevo
Iodine number	211.9

These results show that the water-white distillate conforms to the tests for turpentine and make it similar to that obtained from the Baltic pine in Europe and generally known as French turpentine.

The yellow residue or oil of Douglas fir was next studied in order to determine its nature and probable composition, and the following constants determined:

Specific gravity at 20 deg. C	0.936
Rotation (∝) 20 deg. C	37.6 deg. laevo
Refractivity at 20 deg. C	1.4818
Solubility in 70 per cent alcohol,	49 parts oil in 100 of alcohol
Acid number	1.55
Saponification number	11.1
Iodine number	185.0
Melting point (By solid CO_2)	below 40 deg. C.
Distillation—Initial boiling point is 175 deg., 57.4 per cent distilling between 214 and 226 deg. C.	

Combustion data		
	Hydrogen	11.9 per cent
	Carbon	76.0 "
	Oxygen	12.1 "
	Nitrogen	00.0 "
	Halogen	00.0 "

From these results and others described by Benson and Darrin,[2] the conclusion was reached that at least one third of the oil of Douglas fir consisted of terpineol and that it bore a close resemblance to the pine oil described by Walker[3] and Teeple[4] and for which important industrial applications have been found. Subsequent experiments have shown the terpineol content to be considerably higher, probably close to 48 per cent.

For the steam distillation of green fir boughs and fir needles a small still in the chemical engineering laboratory of the University of Washington was used. From 100 to 200 pounds of green boughs after being cut into small pieces by a wood chipper were distilled for three hours with steam heated to 250 deg. Fahr. in a superheater. The yield of oil thus obtained was 0.45 per cent. It had a yellow-green color with a decidedly pleasant odor. To this oil the name "Fir-leaf oil" is tentatively assigned. Its specific gravity at 20 deg. Cent. is 0.864 and on fractional distillation the following results were obtained.

162–168 deg. C	18	per cent clear water white
168–172 deg. C	23	" " "
172–175 deg. C	18	" " "
175–180 deg. C	15	" less clear, slightly yellow
180–230 deg. C	16	" " " yellow
Residue	10	" brown liquid

The chemical composition as found by combustion analysis is as follows:

C	78.3 per cent
H	11.4 per cent
O	10.3 per cent

On more careful fractionation under diminished pressure it was found that 70 per cent of the fir-leaf oil boiled at the same temperature (65 to 70 deg. Cent. at 20 millimeters) with a specific gravity of 0.8639 at 20 deg. Cent., while the last fraction boiled between 70 and 200 deg. Cent. at 20 millimeters and has a specific gravity of 0.8905 at 20 deg. Cent. It seems probable from the above results and from other incomplete data that fir-leaf oil consists in the main of a terpene and an ester the nature of which is now being determined in the investigation under way, by the usual methods.

Before concluding this portion of the review it should be noted that the process of steam distillation of coniferous wood is often supplemented by extraction with a solvent in order to recover the resin usually present in wood of this character. No apparatus suitable for such extraction having been available, an attempt was made to ascertain the rosin content of the steam distilled chips which had yielded the water-white turpentine and the oil of Douglas fir by percolating hot alcohol over the chips. The yield thus obtained was about 300 pounds calculated to a 4,000 pound sample basis. This extract was dark brown in color, 70 per cent of which was soluble in petroleum naptha (86 deg. Be.) and upon removal of the latter yielded a lemon yellow solid of good transparency and clearness.

II. Destructive Distillation Products.

In order to carry on these tests use was made of a number of industrial plants in operation in the Northwest, all of which, however, have been operating on the waste wood from sawmills. Stumpwood was, therefore, transported to a plant of the destructive distillation type and subjected to the usual process, the yield of products being given in the following table:

Amount of wood distilled	29,160 pounds
Crude turpentine	12.5 gallons
Light oil	25.0 "
Heavy tar	93.9 "
Pyroligneous acid	1,314 "
Charcoal	5,547 pounds

The refining of these products has not by any means become standardized in the Northwest and it is difficult to give in condensed form a statement of the exact products contained in the groups of products mentioned in the table of yields.

From the crude turpentine and light oil mentioned wood turpentine conforming to the usual standards for such turpentine can undoubtedly be obtained. The analyses made in this investigation show the need of methods of refining which differ from those now in use in the Northwest and modifications are being made with this purpose in mind.

The analysis of the tar, however, may be presented as indicative of its nature and consequent uses. These results are given in the tables which follow:

ANALYSIS OF TAR.

Specific gravity at 18 deg. C	1.068
Flash point	105 deg. C.
Fire point	131 deg. C.
Free carbon	1.18 per cent
Viscosity at 100 deg. C. (Engler method)	1.5
Fixed carbon	3.16 per cent
Insoluable in 86 deg. Bé. naphtha	24.27 "
Distillation:	
Water	4.0 per cent
Below 170 deg. C	8.0 "
170–215 degrees	61.0 "
Solid pitch	22.0 "

ANALYSIS OF SOLID PITCH.

Color—Black with bright luster in mass and brown when powdered.	
Fracture	Conchoidal
Melting point	154 deg. C
Free carbon	18.23 per cent
Volatile matter	68.28 "
Fixed carbon	31.54 "
Ash	0.18 "

The results obtained from the analysis of pyroligneous acid are not of a sufficiently definite character to serve as a summation, in part due to the manipulation of the acid in the plant and in part to the methods used for analysis. Modifications, now in progress will, it is believed, give more accurate and conclusive results. From the incomplete data available a conservative estimate places the yield of products which may be obtained from the pyroligneous acid in the test under discussion as follows:

Methyl alcohol containing

Acetone 8 to 10 gallons per 4,000 pounds of wood

Gray acetate of lime .85 pounds per 4,000 pounds of wood

In concluding the review on this process it may be said that the successful utilization of wood waste by destructive distillation depends upon the adoption of successful refining methods and the production of marketable commodities such as wood turpentine, shingle stain oils, tar paints suitable for damp proofing and for metallic surfaces, commercial acetic acid, wood alcohol suitable for denaturing purposes and briquetted charcoal fuel. The contemplates an interesting field but none the less imperative for the success of this process.

III. Hydrolized or Fermentation Products.

The use of wood waste in the Pacific Northwest for the manufacture of ethyl alcohol under the Classen process has been practiced during the past year at one plant. Sulphurous acid was used as the agent for hydrolyzing the sawdust which was obtained from sawmills. The investigations under the writer's direction were not directly concerned with this method of utilization and the yield of ethyl alcohol is not known, except as reported by the officers connected with the plant, who put the yield at 30 proof gallons per ton of theoretically dry sawdust.

The problem of the utilization of the extracted sawdust in this process was, however, made the subject of an investigation in the writer's laboratory. This material, of a dark-brown color and granular in character when dry, It contains approximately 90 per cent of cellulose and

[1] A detailed study of the oil obtained from the leaves or needles of the western red cedar (*Thuja plicata*) has been made by Rose and Livingston in *J. Am. Chem. Soc.* 34.201.

[2] *J. Ind. Eng. Chem.* 3:818. [3] *J. Am. Chem. Soc.* 30:412.

[4] *Mass. Inst. Tech. Bull.* September, 1905.

Steam Distillation Plant Attached to a Sawmill, for recovering values from sawdust.

Gallery in the Steam Distillation Plant for the Treatment of Wood Waste.

gives no reaction for ligno cellulose. The dark color may be removed by boiling with a 10 per cent solution of nitric acid yielding a light or lemon-yellow product, which was found particularly adapted for conversion into pyroxylin and viscose products.

The future of this method of utilization is, however, quite uncertain at this time, since the single plant in operation has encountered many difficulties of a discouraging nature and at this time has ceased to use sawdust as its raw material for the manufacture of ethyl alcohol.

GENERAL SUMMARY.

The waste wood of the Pacific Northwest is of enormous quantity. The experiments above cited show that high-grade commodities may be obtained from this kind of wood by the various processes mentioned. The successful utilization, however, lies in the production of commodities which may be sold in somewhat locally restricted regions and the industries to be built up on waste wood as a raw material cannot, therefore, entirely follow the beaten path which similar industries have pursued in the more populous and congested centers.

Block Signaling and Train Control Report*

Safety in Railway Travel

SYNOPSIS.—A Board was appointed by the Interstate Commerce Commission in 1907 at the direction of Congress, to investigate the use and necessity of railway block signals. In 1908, the work was ordered continued by Congress and broadened to include the study of appliances and systems intended to promote the safety of railway operation. Annual progress reports have been made each year and recently the final report has been issued. A considerable portion is reprinted below, showing the general development and present status of block signals, automatic train stops, rails, ties, high-power headlights, car couplers, and automatic train-pipe connectors.

STATISTICS.

Since the organization of the board in July, 1907, 1,146 devices and systems intended to promote the safety of railroad operation have been brought to the board's attention, and in 1,047 cases complete plans have been furnished. All of these 1,047 cases have been disposed of, opinions regarding the practicability and merit of the devices or systems having been transmitted to the proprietor in each case.

THE BLOCK SYSTEM.

The block-signal system as used on the railways of the United States was one of the two principal subjects assigned to this board for investigation when it was appointed.

The mileage of road block signaled at the beginning of this year was 30 per cent greater than on January 1st, 1908, as shown by the following comparison:

	1912 Miles	1908 Miles
Manual	56,074.8	47,875.7
Automatic	20,334.9	10.803.0
Total	76,409.7	58,678.7

In automatic signaling it will be seen the increase in these four years was almost 100 per cent. The automatic system, superior in many respects to the manual, has in many cases been installed in place of the manual system.

Excepting this statement of mileage, there is nothing of importance to report under this head as having occurred since the last report. The five years' observations of the board may be summarized.

The desirability of using the block system as the only reasonably safe method of regulating the movements of railway trains, which had already been set forth by the Commission in several of its annual reports, was confirmed. The soundness of the principle that the block system is the one and only adequate method now known of spacing trains not only has the constantly renewed indorsement of the majority of prominent railroads, as evidenced by their action in extending its use, but there is a special and significant indorsement in its use on an increasing number of lines which are used only by freight trains. In using the space-interval system on such lines the railroads go further than the board or the Commission has yet proposed to go; and their action tends to disprove the notion that superficial or short-sighted motives, such as advertising, or a narrow consideration of nothing but prospective damage bills for passengers killed or injured, constitute the main reason for introducing the block system.

The simple manual block system under regulations was used on the Northern Pacific—the "A B C system"—increasing its safety without the addition of costly electrical apparatus, and simplifying and cheapening the operation by abolishing the timetable and its complicated rules. But the system was abandoned by the Northern Pacific. Besides the reason for abandonment given by the company, it seems proper to mention what appears to have been a powerful collateral reason, namely, the fact that in returning to the use of the timetable (with or without some manual block signaling carried on under the old regulations) the number of operators (and the amount of salaires paid) could be considerably reduced. A change has been made in the A B C system which has improved it. This is in the provision for moving trains in case of failure of the telegraph wire. Instead of an emergency timetable, to be put into use by the station operators in such a case, the simple train staff, with no electric locking from station to station, is provided. This is simpler, more easily understood, and safer than a timetable, and, we are informed, worked satisfactorily.

AUTOMATIC TRAIN STOPS.

The automatic train stop, the investigation of which was one of the two chief purposes aimed at in the establishment of this board, continues to be a live subject. New data concerning it are being constantly evolved, and serious attention is being given it by competent engineers, so that both the science and the art are being developed along more practical lines than formerly. It is greatly to be regretted that the chief stimulus to these efforts lies in the recurring collisions due to causes that these devices are intended to prevent. The serious collision in the Hoosac Tunnel on the Boston & Maine R.R., near North Adams, Mass., on February 20th, 1912, resulting in the loss of four lives and thousands of dollars' worth of property, draws particular attention to the subject, for not only was that collision ascribed to the failure of the engineman to observe the fixed visual signals, but the locality in which it occurred is one where the use of automatic stops is peculiarly appropriate.

Inductive systems—that is, those in which electrical apparatus on the roadway acts upon electrical apparatus on the train by means of electrostatic or electromagnetic induction, and without any physical contact—continue to offer promise of success. An experimental installation of one such system is being tried in New York city.

In dealing with the mechanical-trip type of train stop the board recognizes as the only adequate standard for such devices that they be so designed as to detect their own failure; that is to say, to be in this respect as safe as electrical apparatus which is arranged on the so called "closed-circuit" principle. It insists that any mechanical trip, to be entirely satisfactory, should be so designed that the breakage or removal of the movable roadside member shall cause an application of the brakes. In a typical apparatus of this kind this object is accomplished by having a rigid roadside member so securely fastened to the track as to be as little susceptible to breakage or removal as a rail of the track itself. This rigid member acts upon the engine member of every train at every point of indication and causes an air-brake valve to be opened. This is the normal operation at the entrance of a train to each block section if the fixed visual signal is at "Stop" or if the block section is obstructed. If, however, the fixed signal is at "Proceed," or the route clear, the movable roadside member comes into operation to engage a member on the engine in such a manner as to prevent the escape of air from the brake pipe due to the previous opening of the valve by the fixed roadside member, or it in some other way forestalls or nullifies its action. Not only does such an arrangement place the mechanical trip within the class of "closed-circuit" devices, but it assures that each apparatus will be operated every time a train passes a signal or a point of indication, thus affording a complete check of its operative condition. In the mechanical-trip systems heretofore tested and those now in use, the engine device and the roadway device never engage except for the purpose of making an emergency stop or when periodically tested, being in this respect in the same category as life preservers and fire extinguishers.

A number of devices have been submitted to the board in which the design of electrical circuits and of the apparatus is apparently of equal merit with that in some devices of the same class which have been tested. The board has not deemed it desirable, however, to conduct tests of two systems embodying the same principle until it has completed at least one test of each of the following types of appratus: (*a*) ground mechanical trip; (*b*) intermittent contact rail; (*c*) devices having insulated short-track sections and insulated wheels or axles; and (*d*) inductive electrical devices. The board has considered it important to have available the information and data obtained from the first test as a guide in future tests of similar devices.

The board greatly regrets that largely through the inability of proprietors of devices to provide proper installations it is not able to present with its final report any data covering tests and devices using insulated short sections of rail and insulated wheels and axles, or of inductive devices.

TRACK STRUCTURE.

Rails.—In the use of steel rails prior to 1900, there were comparatively few rail fractures. During the past ten years the breakage of rails has increased rapidly until

* The abstract here given is reproduced from the *Engineering News*.

now it is of very frequent occurrence. On some roads the number of broken rails found in a single day during the past winter was a matter of grave concern to the officers. It is probably owing to the use of the automatic block system and its track circuit, which in most cases detects broken rails, that more accidents of a serious nature have not resulted from these breakages.

It is of the greatest importance to discover the cause of these rail breakages. The Bureau of Standards in its investigations conducted for the Safety Appliance Division of the Interstate Commerce Commission has performed an excellent service, and this work, if continued, will no doubt contribute very materially to the solution of the problem. Of the number of things pointed out in the report of the Bureau of Standards two are conspicuous: (1) That by the present method of inspection faulty rails are passed for shipment from the mills, and (2) that rails are overloaded.

Since 1900, an effort has been made by the mills to hasten the metallurgical process, but the soundness of the metal has been decreased. One obvious method of improving the quality of rails would appear to be to take all the time needed to insure sound rails. Since 1900 cars and engines have greatly increased in weight. Simultaneously, high speeds have become more and more common. It requires only the briefest consideration to realize that the magnitude of rail shocks is directly proportional to the weight and to the square of the speed. Thus, if both the weight and the speed have been doubled, the intensity of the shock has been increased eight times.

It is true that the rail itself has also been increased in weight, rails weighing 100 pounds per yard being now frequently used where formerly rails weighing from 60 to 80 pounds per yard were used. As a standard 100-pound rail has a strength of only about two and one half times that of a 60-pound rail and one and one half times that of an 80-pound rail, it is obvious that with the greater weights and speeds the rail load has increased quite out of proportion to the increase of rail strength. The importance of the rail problem is so great as to warrant giving to it most careful and systematic investigation.

Ties and Roadbed.—The board has devoted considerable time to the investigation of various designs of ties intended as substitutes for wood ties. The most that can be said for the many designs that have been submitted is that in general they indicate only in moderate degree an appreciation of the real problem to be solved.

The principal materials other than wood, which have been used or suggested for railroad ties are steel, concrete and combinations of these two materials. In this country the use of steel is slight as compared with foreign countries, but on a few roads, the Bessemer & Lake Erie in particular, the I-beam form of steel tie has been given a thorough trial. From the standpoint of strength, durability and adaptability to the use of proper track fastenings this form of steel tie can be said to be adequate. It furnishes a good support for vertical loads, and proper resistance for forces in compression, tension and bending. With stone ballast it holds the track in adjustment more satisfactorily than with light ballast. Projecting flanges have been used to secure greater resistance against displacement, and no reason is apparent why such flanges should not prove adequate.

Another prominent form of steel tie is the trough-shaped section, some having the opening of the trough downward and others upward. The dome or saucer-shaped section has also been used to some extent, particularly in Mexico. While moderate success has attended the use of the trough-shaped section with the opening upward, those forms with the opening downward have not met with such success that their use has been continued. This is apparently due to the working of the ties in the ballast, although in some kinds of ballast they have given satisfactory service.

Concrete ties are found in only a few experimental installations. These consist either of concrete, plain or reinforced, made in the same shape as wooden ties, or of solid blocks of concrete under each rail, opposite blocks being connected by metal tie bars which also take part in forming the track fastenings. Two installations of concrete ties were examined by the board, one on the Erie R.R., the other on an electric line near Buffalo. Those on the Erie, after several years' service on a branch line, were put into the main track, near Salamanca, but after a few months' trial they were removed and it is understood their use has been discontinued.

The examination of the concrete ties in use near Buffalo and Salamanca and of the steel ties on the Bessemer & Lake Erie indicates that when the track is ballasted with stone and is properly drained, the fear of a too rigid roadbed from the use of materials less elastic than wood is in large measure unfounded.

The use of concrete ties reinforced with steel must remain a question for the future, as no examples of this type are in use.

The fundamental defect in design, which is the most apparent, is failure to realize and appreciate the overturning moment due to the wheel flange pressure against the head of the rail. It is not sufficient that a tie should support the vertical loads and resist direct horizontal thrust and the tendency of the track to move laterally and longitudinally, but this overturning moment must be resisted. This requires that the tie must be a beam to resist bending, so that the overturning stresses may be properly transmitted and resisted.

In order that the tie may properly support the stresses transmitted to it by the rail, a suitable fastening of the rails to the ties is most essential. The driven spike commonly used with wooden ties is, of course, impracticable for steel, concrete, or composite ties. The type of track fastening will necessarily vary not only with the material of the tie, but also with its form. A common defect found in many designs is the complication of the rail fastenings. Where bolts are used both the head and the nut should be accessible and the bolts should be capable of renewal without disturbing the ballast to any extent. In many designs of track structure an outside rail chair or brace is used to prevent the overturning of the rails. It is generally formed to fit the contour of the rail, and intended to act as a compression member only. The strength of the rail section itself when subjected to outward bending is more than sufficient to prevent overturning if the bottome flange of the rail is securely held down to the tie. Thus held, there would be no need to resort to outside braces.

A large number of designs presented indicate that the inventors are quite unfamiliar with the ballast and weather conditions encountered on many railroads, particularly in winter, as they make no provision for shimming. Under the action of frost the roadbed heaves, often to a considerable extent and frequently in a very uneven manner. The ties are frozen in the ground, and such undulations of surface are caused by the uneven freezing or heaving that the rails must be shimmed or blocked up above the surface of many of the ties in order to produce a rail surface sufficiently even to carry traffic safely. Under the conditions existing on a large proportion of the railroads in this country the means of adjustment of rail to tie must be such as to admit of this blocking up or shimming, though as the roadbed becomes older and better compacted and as stone ballast is introduced to a sufficient depth the necessity for so doing diminishes.

To provide adequately for shimming or for widening the gage appears to have been a difficult problem for inventors, as it involves the use of adjustable fastenings, with consequent chance for lost motion and change of adjustment. In turnouts and in main-track curves of less than certain radius it is desirable to widen the gage of the track, and many designs of ties submitted make no provision for so doing.

Another factor having to do with both form and material is the question of insulation of the rails on the one side of the track from those on the other, where electric track circuits are used for signaling. The electric track circuit is coming more and more into use, and no design of tie can be deemed suitable for general use which does not adequately provide for insulation of the rails from the ties.

HEADLIGHTS.

From a study of the devices submitted, the board believes that it is not practicable properly to control the direction of a headlight beam through the swiveling of the trucks or by any relation of the train or engine to the track upon which it is running, but that simple mechanical means may readily be designed to swing the headlight so that the engineman may, within limits, have complete control over the direction of the beam.

As a general conclusion regarding locomotive headlights, the board believes that a headlight should be considered either as simply a marker to indicate to stationmen and other persons concerned the approach of a train or, if it is to be used as more than a marker and is intended to be used for the detection of obstructions on the track at a sufficient distance to enable a train to be brought to a stop after they are sighted, the headlight should be a high-power light having both the direction and intensity of the beam controllable by the engineman. The control of the intensity of the beam by the engineman directly from the cab is regarded as a necessity, as when meeting or passing other trains and for preventing improper reading of fixed or classification signals. Perhaps the most common and the most weighty objection to the use of high-power headlights is that an engineman running in one direction is dazzled by the light of an engine coming toward him. To meet this objection it is deemed important that every high-power headlight should be so arranged that the engineman can occult it at will.

CAR COUPLERS.

Since the passage of the sundry civil act of May 27th, 1908, which directed the Commission to examine and report upon all systems or appliances intended to promote the safety of railway operation, the board has examined plans and specifications, as well as models, of numerous automatic car couplers. By reason of the requirements of uniformity and interchangeability to which such devices must conform, the inventors of car couplers are limited to a vertical-plane type of coupler which follows the contour lines prescribed by the Master Car Builders' Association, and their efforts must be confined to effecting improvements in design of the working parts of couplers of the M. C. B. type. The Federal safety-appliance law, which requires the use of couplers that will couple automatically by impact and which can be both coupled and uncoupled without the necessity of men going between the ends of the cars, together with the great increase in size and weight of trains within recent years, have rendered many of the earlier designs of the M. C. B. type of coupler unserviceable. To meet the new conditions, there has of necessity been a notable improvement in the mechanical design and construction of the working parts of couplers, while the type and contour lines prescribed by the Master Car Builders' Association have remained unchanged.

The knuckle-opening device is now in general use and is recognized as a necessary feature of the standard M. C. B. coupler. All M. C B. couplers now manufactured embody some form of mechanism for automatically opening the knuckle. The use of a centering device is not so general, but the utility of some form of centering device is well recognized, and such devices are coming into use.

Most of the coupler designs that have been offered to the board for examination were considered impracticable, or inferior to couplers already in use. As an aid to inexperienced inventors, the board formulated the following desirable characteristics for automatic car couplers. They should:

(1) Conform to M. C. B. standard drawings and contour lines.

(2) Have a lock-set within the head of the coupler.

(3) Be so designed that they will not part when the knuckle pin is removed or broken.

(4) Be so designed that movement of the uncoupling means to unlock the coupler will open the knuckle.

(5) Be so designed that they will couple with each other, with either or both knuckles open.

(6) Be so designed that the lock lift will not be more than 6 inches.

(7) Have the fewest possible number of parts; and their operation must in no way depend upon the use of springs.

(8) Have the tail of the knuckle and the lock bearing so located that the axis of the drawbar will pass centrally through the engaging surfaces of the knuckle tail and the lock block, which must be of sufficient area to avoid excessive wear.

(9) Have the locking pin so designed that it will assume locking position freely by gravity, without being compelled to overcome friction or resistance from the unlocking means.

It is believed that the Master Car Builders' Association has the coupler problem fairly well in hand, and that couplers are now being furnished which meet the demands of safety as fully as can be expected, owing to the restrictions of manufacture and in view of the exceptionally hard service to which such appliances are subjected.

AUTOMATIC CONNECTORS.

The use of a practical device for automatically connecting the air-brake, steam-heat, and signal-pipe lines through a train is desirable, not alone from the standpoint of safety, but also because of economy and the saving of time in train operation.

The side-port and butt-face types of connectors cannot be used together, nor can the pin-and-funnel and wing types of gathering devices be used together. It is apparent, therefore, that until some one type has been decided upon by adequate authority and definitely adopted as standard, little progress in equipment for actual serivce can be hoped for. It is also true that because of the manifest impossibility of equipping all cars in service at the same time, any hose connector to be serviceable must be so constructed that it can be coupled to the couplings now in common use. The absence of such a provision in a connector is sufficient to prevent its adoption for general use. Another important question is the stopping of leaks and making light repairs. From an operating standpoint it is clearly impracticable to have an engine at hand for the purpose of separating cars whenever it becomes necessary to remove defective gaskets and insert new ones. Some means must be provided for doing such work while the connector heads are coupled together.

The connector designer must provide for additional requirements that are more severe than any which the car-coupler designer has to meet. Whatever form of gathering and registering device may be used with a connector, it is apparent that it must be capable of considerable distortion without destroying the ability of the connectors to register and lock in position when their faces are brought together. Not only for convenience and for obvious mechanical reasons, but also to make it possible to couple hand hose with the automatic connectors during the transition period, connectors should be located directly below the car coupler and in a vertical plane containing the center line of the coupler. To meet the requirements of the Master Car Builders' Association the center line of the connector head must not ex-

tend downward farther than 17½ inches below the horizontal center line of the drawbar. The central axis of the connector head must also be the center line of the air-brake port.

Some of the connectors which had been presented for examination possess theoretically good features which would seem to render them entirely practicable for general use. The usefulness of these theoretically good features, however, can only be determined by extensive tests of the connectors in which they are embodied, under the most severe working conditions which such devices are likely to meet in actual service. The board, therefore, arranged with the officers of the Great Northern Railway, for the equipment (with the Robinson connector) of 50 high-capacity cars. These cars are used in ore service on the Marcus division, on track having heavy grades and excessive curvature. The cars are heavily loaded in service and high brake-pipe pressure is used, so that the conditions are such as should afford a thorough test of the practicability of the connector for use in general railway service.

Owing to manufacturing difficulties encountered by the proprietors of the device the equipment was delayed far beyond the time of its expected completion, and the board is therefore unable in this report to present any details concerning the performance of this connector.

INSPECTIONS.

In previous reports references have been made to inspections carried on by the board covering signaling practices, methods of operation, and conditions of roadway. These inspections have been continued. They have been made for the double purpose of (1) carrying on the investigation relating to block-signal systems and other devices intended to promote safety in railway travel, and (2) to set forth in a summary for the benefit of the officers of railroads any bad practices or unsafe conditions observed.

In signaling, many instances have been found where signals were out of order; portions of the track without track-circuit protection; signals improperly located amid surroundings which tend to create confusion in their observance; lack of sufficient tools, lanterns, and flags; giving of hand signals from interlocking towers; drawbridges without any kind of protection; and many cases where interlocking towers were found in filthy condition. In methods of operation, practices such as the handling of train orders in cramped quarters and amid confusing surroundings; allowing some trains to pass block signals in the stop position without stopping; practices connected with the flagging of trains, particularly trains which are not fully manned, thus requiring the flagman to perform services liable unduly to take his attention away from flagging, are some of the many defects or deficiencies to which our attention has been called.

GENERAL CONDITIONS AFFECTING SAFETY.

In discussing this subject it may be assumed at the outset that railroad officers and employees are as anxious to do everything in their power to promote safety as the public is to have safeguards provided, and that railroad officers and employees are not immune to the horrors of a terrible wreck. The railroad officer responsible for results does his utmost to meet the demands made on him. His first responsibility, as he sees it, is to provide earnings. It is but natural, therefore, that he has given chief attention to the conditions directly affecting the financial end of the business, and less attention to the conditions affecting safety. Safety he very much desires, but earnings he must have.

The public should squarely face its share in the responsibility for safety. The comfort and luxury which it now demands are costly. The high-speed train which was a special event 20 years ago is now a feature of the regular schedules. The American people cannot wait; they crowd the steps to get on a train and the aisles to get off. Comforts and luxuries are demanded without increase of expense to the traveler; not only that, but with a very general demand for a decrease in prices. Every added demand upon existing facilities and methods introduces sources of danger. As the demand does not diminish, it seems necessary that methods and facilities must improve if the standard of safety is to be maintained.

As regards methods, it may be said that on the large majority of American railroads excellence of administration is nullified by faulty organization, magnification of individual function to the detriment of team work, and by an almost entire absence of a definite system of broad training of subordinates for higher duties. These, and the shifting of responsibility from one officer or department to another, prevent the attainment of that high order of discipline and *morale* which must be had if carelessness is to be overcome and skill and painstaking loyalty govern the acts of the men on whom the public must depend for safety in travel. As has been observed in former reports, this condition is largely due to causes which have their roots in the conditions of society in America.

While the deficiencies noted above may explain, they can hardly excuse failure to take greater advantage of the facilities for promoting safety which already exist or are ready for final development by the railroads. The railways have been slow in installing the block system, long since demonstrated to be the prime requisite for safety against collision. The railroads have failed to investigate as fully as they should the availability of devices to supplement the block system as now used, and which if adopted would add directly to the safety secured by existing means. This question of neglect of definite measures affects the public also. The failure of the Government to require the installation of the block system is a definite feature of recent congressional history, there being more and stronger reasons to require this improvement than exist for the use of some other safety devices now required by law. Intelligent co-operation by the States and the Federal Government in establishing more uniform requirements for the operation of railroads would result in marked advancement and help to do away with the uncertainty felt by railroads as to their future.

CONCLUSIONS.

In concluding its final report, the board summarizes the recommendations made in its several reports as follows:

(1) The compulsory adoption by all interstate railroads of the block system. That system has long since passed out of the experimental stage. As regards the manual block system this recommendation implies the careful selection and thorough training of the block signalmen and the constant, regular and thorough inspection of signal operation and methods. The automatic block system must be carefully and thoroughly installed and constantly inspected.

(2) The development of the automatic train stop has proceeded far enough to warrant the expectation that by its use greater safety can be secured in the operation of trains. Railroads should be given to understand that the automatic train stop must be developed by them as rapidly as possible.

(3) Railroad tracks should be properly inclosed and the laws against trespassing thereon enforced. Grade separation should be encouraged and in certain localities required.

(4) The payment of pensions by the railroad companies to their superannuated employees would do much toward creating loyalty and stability in railroad organizations.

(5) There should be more complete co-operation of the State and Federal Governments on the one hand and railroad companies on the other, in order to bring about more stable conditions throughout the entire country. Piecemeal legislation should be brought together and harmonized into general enactments, comprehensive in character and based on the best standards of practice. The board recommends that the enforcement of this general legislation be intrusted to a body having powers similar to those now provided for and administered by the Railway Department of the British Board of Trade.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

The Sanitary Sleeping Car

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

Naturally, railroads and car companies are not anxious to make many changes in equipment. The units of rolling-stock being in the hundreds of thousands, the slightest change or addition to each one piles up so formidably that much-desired dividends are eaten up, hence are improvements rather scowled upon.

I have had very much to do with railroads and fully appreciate their position, but also have I traveled a great deal, and therefore realize that after all the traveler receives very little for his money, especially in so far as the sleeping car service is concerned. It is also a fact that most of the improvements that have been made were suggested and insisted upon from *outside* the company, and have only become accomplished facts after much publicity and a good hard fight. The matter of ventilation and greater hygenic care of sleeping cars is just now attracting very much attention, and many newspapers and magazines are actively taking up the matter and urging reform. The thing will soon assume the form of a well-defined "movement," and when it gets big enough, why, we may expect results.

A great deal could and should be done to make sleeping cars less of disease-breeders, healthier abodes than they now are. If anyone had deliberately undertaken to make them as bad as possible they couldn't have made those cars worse than they are, woolly carpets, fuzzy plush upholstering, woolly draperies and all that sore of thing. The bedding is the least damnable of all, for mattresses and pillows are at least covered over with freshly laundered sheets and cases that keep one from immediate contact with the nasty ticking of the bedding whereon have slept, just before you, tubercular and other diseased humans. Doctors tell me that the curtains are the very worst feature. The cleaning of a sleeping car *via* the vacuum cleaner appears very thorough and is comparatively so, as far as dust is concerned, but it is utterly ineffective against germs.

The floor of the car should be of rubber tiles or something as "refractory," the upholstering should be of leather or such non-absorbent surface. The curtains should be rubberized canvas, decorated as much as one wishes and as dark colors as desired, but in applied colors, and the bed ticking should be rubberized or mercerized, so that not only could the vacuum cleaner remove all the dust, but that the curtains, the floors, the seats, the bedding, could at frequent intervals (after each trip, surely) could be thoroughly sponged over or sprayed with some form of liquid antiseptic or germ destroyer. Then let as little dust into the car as possible and make it as habitable as possible, and give it as pure air as possible by properly ventilating it mechanically.

We have gotten so that we can handle our theaters, libraries, hospitals, and other such buildings in a sensible and hygienic manner. The best of them are made so that they are sealed up and the air circulation is provided artificially, purified and under perfect control. That is what we ought to do with the sleeping car. Close the windows and so-called "ventilators" and provide artificial ventilation, an abundance of pure, clean, washed air, cooled in summer and heated in winter, and supplied at very little more than the cost of installation, for each car carries and virtually generates its own power. And even if it does cost a little the public has reason to demand it. Space, comfort, and all such considerations are doled out at a lesser pro rata of the charges on a sleeping car than in any theater, hotel or hospital. This safeguarding of health, the providing of maximum comfort and safety on a sleeping car is the public's right, and it is simply the part of the public to see that it gets these things.

My scheme is simple and can be briefly described as follows: There should be an air inlet on the side and at one end of the car, where the old heater used to be or at the porter's closet and low down, so as to be in the best strata of air the train is traveling in. On the roof it would catch all the gases; under the car it would get all the dust; at the side about seat level cinders only have to be contended with. This inlet should be internally beveled so as to catch the maximum of air whichever way the car is traveling, and should be provided with an automatically closing shutter so as to prevent suction backward. This opening to be well-screened against cinders. Inside of this opening a powerful fan or blower would be operated, of sufficient capacity to introduce a given quantity of air a minute for every passenger. The blower would propel the air through another screen, over which a small quantity of water would be running so as to keep the screen wet, thus "washing" the air and catching every particle of dust. Back of that would be copper coils, a bank of flat pipes, for steam in winter time and for refrigerating ammonia in summer. In winter time the air would simply be warmed so that there wouldn't be a cold blast in the car, but not sufficiently heated to be the sole means of heating. The present direct heating pipes could be retained, but should be properly controlled by automatic regulation. From the air chamber containing this heating or cooling coil, there would be provided ducts or pipes under the floor to different points of the car, preferably between the windows just under the top berths and at other points above the top berths, and so graduated that an abundance of air would be introduced without making a blast of it. This would provide a large supply of air in each berth, even though the curtains be tightly drawn. Then in the floor at different points under the seats would be exhaust openings for the expulsion of the foul air. The size of the fans and all that sort of thing is a matter of detail and to be finely adjusted. So that the inlet capacity may be sufficiently in excess of the outlet to insure that there would always be a pressure of good pure air in the car, yet a continual circulation that would make the car absolutely hygienic, comfortable and a desirable abiding place.

The machinery of the affair could be geared directly to the wheels, then switched to the same electric power that supplies the light when the cars are in the stations, or operated from the motors run by the engines when cars are not in motion. All that constitutes more detail. The principle of the thing is what I am driving at and what I would like to see your journal take up and urge and finally bring to a realization.

Washington, D. C. F. W. FITZPATRICK.

NEW BOOKS, ETC.

THE DYNAMICS OF MECHANICAL FLIGHT. By Sir G. Greenhill. New York: D. Van Nostrand Company, 1912. 8vo; 121 pp; illustrated. Price, $2.50 net.

Sir G. Greenhill's work represents six lectures delivered before the Imperial College of Science and Technology. The first discusses the general principles of flight; the second deals with calculation of thrust and center of pressure; the third presents the Helmholtz-Kirchh of discontinuous stream-line theory; the fourth is a somewhat superficial exposition of gyroscopic action; the fifth lecture deplores the conflicting notation employed by those writing of the screw propeller, but points out the general agreement of the formulæ for the thrust, and continues with Rankin's treatment of the subject, afterward presenting such theories as seem capable of verification on a large scale. The final lecture discusses the pneumatical theory involved in the airship. In spite of a myth-permeated introduction, some typographical errors—flight, lift and drift appearing more than once as "flight, *light* and drift"—and a few statements of doubtful authenticity, the work may be beneficially studied as a generally clear and readable explanation of dynamical principles.

THE BUSINESS OF BOOKBINDING. By Alex. J. Philip. London; Stanley Paul & Co, 1912. 8vo.; 224 pp.; illustrated. Price, $2.40.

The reader who searches the pages of Mr. Philip's latest work for disclosures of trade secrets will be disappointed. The author has written for binders, publishers, librarians, and the general reader a very practical handbook, which will tend to stem the tide of cheap, worthless bindings that have been placed upon the market of late in an effort to take advantage of the greater margin of profit.

THICK-LENS OPTICS. An Elementary Treatise for the Student and the Amateur. By Arthur Latham Baker, Ph.D. New York: D. Van Nostrand Company, 1912. 8vo; 131 pp.; illustrated. Price, $1.50 net.

"Thick-Lens Optics" is a working manual written for those who wish to intelligently apprize what is going on in their camera, their microscope, or their telescope. It is an outgrowth of the difficulty which the author encountered in finding answers to his questions in the accessible literature of the subject.

THE PARTY BOOK. By Winnifred Fales and Mary H. Northend. Boston: Little, Brown & Co., 1912. 8vo.; 354 pp.; illustrated. Price, $2 net.

While making no claim to strict originality, "The Party Book" is not the usual haphazard gathering of old material, and there are no hostesses but may profit in some measure by its fresh viewpoints, its dainty decorative schemes, and its games and recreations.

THE MOSQUITO. Its Relation to Disease and Its Extermination. By Alvah H. Doty. New York: D Appleton & Co., 1912. 16mo.; 79 pp.; illustrated.

"The Mosquito" is a brief study, by the former health officer of the port of New York, of the propagation and habits of the various insects of the genus *Culex* that are so dangerous as disease carriers. Their length of life, the distances they travel, and their modes of hibernation are set before the reader, and methods for their extermination are suggested.

ENGINEERING AND METALLURGICAL BOOKS. 1907–1911. By R. A. Peddie. New York: D. Van Nostrand Company, 1912. 12mo.; 206 pp. Price, $1.50 net.

This catalogue gives the full titles, arranged under subject headings, of all British and American books on engineering, metallurgy, and similar subjects, for the five years ending December 31, 1911. For the further convenience of those who consult the catalogue, there is appended a list of authors' names and a table giving the subject headings in classified order.

RADFORD'S BRICK HOUSES. And How To Build Them. Selected and Compiled by William A. Radford. Chicago: The Radford Architectural Company. 4to.; 219 pp.; illustrated. Price, $1.

"Brick Houses" is a collection of original designs for houses, apartments, stores, and garages, with instruction in the manufacture of brick and its practical uses as a building material. While economy and utility seem to be the aim of the collection, artistic merit has by no means been overlooked.

MODERN PARK CEMETARIES. By Howard Evarts Weed, M.S. Chicago: R. J. Haight, 1912. 12mo.; 145 pp; illustrated.

The author is doubtless right when he states that the greater number of those engaged in cemetary work have drifted into it from other fields, and that they must have been handicapped through lack of suitable text-books is also no doubt true. His compact volume furnishes a condensed course of instruction. Hints on the organization and ownership of cemeteries are followed by a consideration of suitable location, by suggestions for layout, by discussions of construction work and landscape development, and by information regarding the superintendent and his duties.

STEAM BOILERS AND BOILER ACCESSORIES. By W. Inchley, B.Sc. New York: Longmans, Green & Co., 1912. 12mo.; 412 pp.; illustrated. Price, $2.40 net.

The author has been successful in no small degree in his endeavor to compress the subject of boiler construction and operation into the limits of a small, handy volume. Without going into such fine details as the pitch of rivets and the strength of plates, the general principles of the strength of parts are laid down, the most commonly-used types of boilers are described, the theory of combustion and steam generation is considered, and the practical running of boilers receives the attention worthy of its importance.

ANALYSIS OF PAINT AND VARNISH PRODUCTS. By Clifford Dyer Holley, M.S., Ph.D. New York: John Wiley & Sons, 1912. 8vo.; 292 pp.; illustrated. Price, $2.50.

The work is designed to fill the need for a more comprehensive exposition of the analysis and valuation of paint products than has up to the present time been published. In the matter of valuation, the consumer relies almost entirely upon the chemist, and it is of great importance that the chemist employ rapid and accurate methods in arriving at his conclusions. The material of the present volume largely follows that of the author's earlier work, "Analysis of Mixed Paints, Color Pigments, and Varnishes," but broadened scope, the introduction of new methods, and the discussion of new products give the book a right to be regarded as essentially an original issue.

ELEMENTS OF DRAWINGS. By George F. Blessing, M.E., Ph.D., and Lewis A. Darling, E. in M.E. New York: John Wiley & Sons, 1912. 8vo.; 193 pp.; illustrated. Price, $1.50 net.

This text-book was written at the request of Prof. Kimball of Cornell University, with the object of obtaining a book nicely suited to the needs of the Department of Machine Design and Construction of Sibley College. Its general principles and methods have been in use there for a long time, and have been amply justified by results. The avowed aims of the work are to teach the student how to think over the drawing board, and to lead him to consider the relation drawing bears to design, shop processes, and shop organization.

TREATISE ON HYDRAULICS. By Mansfield Merriman. Ninth edition, revised and reset with the assistance of Thaddeus Merriman. New York: John Wiley & Sons, 1912. 8vo.; 565 pp.; illustrated. Price, $4 net.

This is the ninth edition of a favorably known work which first appeared in 1889 and has in successive editions fully kept pace with the great advances of its subject. In this edition the work appears fully rewritten and reset, with entirely new material bearing upon hydraulic instruments, methods of measurement, oblique weirs, submerged tubes, regulating devices for pipes, conduits, dams, backwater, rainfall, evaporation, and run-off. The tables of coefficients have been revised and extended to include the knowledge gained in recent experiments.

THE BRITISH JOURNAL PHOTOGRAPHIC ALMANAC, and Photographer's Daily Companion. 1913. Edited by George E. Brown, F.I.O. New York: George Murphy, Inc. 12mo.; 1,448 pp.; illustrated. Price, paper, 50 cents; cloth, $1.

The fact that the text of this annual is confined to less than one third of its bulk, and that the remainder of it is given over to advertising, scarcely detracts from its value; for the advertising sections are most interesting, and include reproductions that have real artistic value. Among the contents proper are papers on the practical methods of telephotography, on the apparatus and equipment of the studio and the dark room, on negative and printing processes, on color photography, and on recent novelties in apparatus.

TEXT-BOOK OF MECHANICS. By Louis A. Martin, Jr. Vol. IV. Applied Statics. New York: John Wiley & Sons, 1913. 12mo.; 198 pp.; illustrated. Price, $1.50 net.

In this text-book, statics is applied both to structures and to machines. It aims to introduce the student to mechanical as well as to structural engineering. A previous volume dealt with the mechanics of materials, and a projected volume on kinetics will complete the triad on applied mechanics.

BUILDING STONES AND CLAY PRODUCTS. A Handbook for Architects. By Heinrich Ries, Ph.D. New York: John Wiley & Sons, 1912. 8vo.; xiii+415 pp.; 59 full-page half-tone plates and 20 figures. Price, $3 net.

The work in hand endeavors to sufficiently acquaint the architect with the properties and durabilities of the various kinds of stone without going too deeply into the geology of the subject. The illustrations are an important feature of the volume. There are photomicrographs showing grain and texture, cuts showing breaks in set stone caused by strain due to settling of the building, etc. The effect of fire on granite columns is graphically set before us in the case of the U. S. Public Storehouse at Baltimore. There are buildings, monuments, and quarries illustrative of the statements made by the author, and a map giving the distribution of igneous rocks and gneisses in the United States.

THE ELEMENTS OF MACHINE DESIGN. Part II. By W. Cawthorne Unwin, F.R.S., LL.D., and A. L. Mellanby, D.Sc. New York; Longmans, Green & Co., 1912. 8vo.; 426 pp.; illustrated. Price, $2.50.

The first volume of this work made a good presentation of the general principles of machine design. The second volume is devoted almost entirely to steam-engine details. The work may be used in the shop and the drafting room as a well-arranged reference book of designs, rules, and data, or it may be adopted as a text-book in engineering classes.

MACHINE DESIGN. Hoists, Derricks, Cranes. By H. D. Hess, M.E. Philadelphia: J. B. Lippincott Company, 1912. 8vo.; 368 pp.; 318 illustrations in text and 18 inserts. Price, $5 net.

The work is primarily intended for use in technical schools and colleges, but will also prove helpful in draughting rooms where general machine design occupies the attention. The author believes that the best general training and practice is furnished by a study of the design of cranes, since their details present machine elements common to so many other devices in constant use.

WATER ANALYSIS FOR SANITARY AND TECHNICAL PURPOSES. By Herbert B. Stocks. Philadelphia: J. B. Lippincott Company, 1912. 8vo.; 136 pp.; 8 illustrations.

Duly taking into consideration the brevity of the treatise, the condensed information it offers will still be of the greatest assistance to beginners. The more useful and most used processes of water analysis are given quite fully, physical examination being disposed of in a short preliminary chapter, while the remainder of the work directs attention to such subjects as quantitative analyses for sanitary purposes, quantiative analyses for the mineral constituents, deleterious metals, and gases contained in solution.

A TEXT-BOOK OF RAND METALLURGICAL PRACTICE. Designed as a "Working Tool" and Practical Guide for Metallurgists upon the Witwatersrand and Other Similar Fields. Volume I. Philadelphia: J. B. Lippincott Company 8vo; 468 pp.; 128 illustrations.

Those in any way occupied or interested in ore reduction and treatment practice will eagerly welcome these volumes written by nine experts for the practical use of mill and cyanide men. The two volumes which comprise the work carry detailed description of actual daily routine on the Rand. The history of the subject has been given sufficiently to enable the reader to follow the evolution of existing methods from the crude procedure of former days, but the bulk of the work devoted to the various branches of present-day activity—sorting and breaking, stamp-milling, tube-milling, treatment of sand, slime, precipitation, smelting, assaying, and testing.

THE ART TREASURES OF WASHINGTON. By Helen W. Henderson. Boston: L. C. Page & Co., 1912. 8vo.; 398 pp; illustrated. Price, $3 net.

In a series entitled "The Art Galleries of America," the publishers are putting out an educative and pleasure-imparting set of volumes that should not fail to forward the cause of art in this country. The work in hand starts with the beauties of the city of Washington itself, and proceeds to give an account of the Corcoran Gallery, the National Gallery and Museum, and the works of art in the Capitol and in the Library of Congress.

COLOR-MUSIC. The Art of Mobile Color. By A. Wallace Rimington, A.R.E., R.B.A. New York: Frederick A. Stokes Company. 8vo.; 185 pp.; illustrated.

The analogies between music and color have often been noticed and commented upon. It has remained for Prof. Rimington to develop a color-organ, by which the manipulation of the keys is made to project upon a white screen the most wonderful colors and combinations of color, with musical accompaniment.

MINERALOGY. An Introduction to the Theoretical and Practical Study of Minerals. By Alexander Hamilton Phillips, D.Sc. New York: The Macmillan Company, 1912. 8vo.; 699 pp.; illustrated. Price, $3.75 net

Under three headings—crystallography, descriptive mineralogy, and determinative mineralogy—Prof. Phillips of Princeton University has brought together within the scope of one volume such facts and principles as a beginner needs to know. In dealing with crystallography, only graphical solutions of the problems are given, mathematics being left for more advanced courses. The second part, descriptive mineralogy, includes some 235 species of minerals, and a general knowledge of chemistry is necessary to a thorough understanding. The final division of the work describes instruments, reagents, and chemical tests, with various tables and lists.

THE FOUR GARDENS. By Handasyde. Philadelphia: J. B. Lippincott Company. 8vo.; 161 pp.; illustrated.

All who love gardens and flowers, and children and human nature, will appreciate the four slight sketches embodied in this book. They are scarcely stories, from our modern, plot-demanding point of view; yet the touch is sure, though refined, and a certain quaint humor pervades the atmosphere.

THE ART OF THE UFFIZI PALACE AND THE FLORENCE ACADEMY. By Charles C. Heyl. Boston: L. C. Page & Co, 1912. 12mo.; 364 pp.; illustrated. Price, $2 net.

Art has its physiology and its psychology. It is rather for those who worship the soul of art, than for those connoisseurs who dispute over its clay, that this work has been prepared. The great paintings and sculptures that now repose in Florence are most sympathetically described, and a generous group is presented in admirable full-page plates in duogravure. Throughout, the aim is to give the most intense enjoyment while establishing understanding and appreciation.

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